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Volume XXXVII SEPTEMBER, 1944 No. 3

THE LIFE HISTORY OF THE TICK ORNITHODOROS CORIACEUS KOCH (ARGASIDAE)[1]

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The tick *Ornithodoros coriaceus* was described by Koch (1844) and redescribed by Nuttall, Warburton, Cooper, and Robinson (1908). Herms (1916) has given the distribution in California, where it is known as the pajaroello. It is not known to occur elsewhere in the United States. The distribution in Mexico, where it is known as the tlalaja, has been given by Hoffmann (1930). True (1932) studied the anatomy and histology of the alimentary canal in this species. Most textbooks on medical entomology refer to the severity of its bite.

Herms (1916) published a brief account of the life history of this species. He recorded an incubation period of 21 days at 26° C., a complete developmental cycle (egg to egg) of 15 months, and an individual developmental period (egg to adult) of 159 days for a male and 343 days for a female. He observed one female to lay 10 lots of eggs, as many as 802 eggs in a single lot, and 1,158 eggs in seven lots in a single season, and observed first-stage nymphs to molt without feeding. He did not indicate the extent of his material, but the foregoing specific records were taken from only three individual ticks, a female collected in nature and a male and female reared from eggs. He gave the durations of the larval and nymphal instars for the reared female. In addition, he reported a minimum larval period of 19 days, and stated that four to seven molts occur during development, indicating one larval and three to six nymphal stages.

Since the small number of records on which Herms' paper was

[1]A portion of a thesis submitted to the Graduate Council of the George Washington University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

[2]The writer is indebted to various members of the faculty of the George Wash. ngton University and to F. C. Bishopp, Assistant Chief of the Bureau of Entomology and Plant Quarantine, for helpful suggestions and criticisms, and to C. B. Othier, of Salinas, Calif., and R. J. O'Bryant and C. S. Robinson, of the Forest Service of the United States Department of Agriculture, Santa Barbara National Forest, for their kindness in submitting living material.

apparently based made additional observations on this species seem desirable, work on its biology was begun when living specimens came to hand.

THE EGG

The following incubation records were obtained at Washington, D. C., on nine lots of eggs from females engorged in the laboratory: At room temperatures in June, July, and August, 10 days at an average

TABLE I

ENGORGEMENT OF LARVAE OF *Ornithodoros coriaceus*

DATE PLACED ON HOST	HOST	NUMBER APPLIED	NUMBER OF ENGORGED LARVAE DROPPED ON THE SPECIFIED DAY AFTER ATTACHING														Total
			5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1934																	
Oct. 9	Guinea pig	8			2		2										4
Oct. 23	Guinea pig				19	8	8	2									37
Dec. 11	Guinea pig	11			2		2	1									5
Dec. 14	Guinea pig	70			1	4	1	3	6	2	3	2					22
1935																	
Jan. 22	Guinea pig	38				4		2	1	3							10
July 19	Guinea pig	50				2	6	8		4		4					24
Aug. 19	Rabbit	60				9	5	10	3								27
Aug. 20	Rabbit	63			30	19	12										61
Aug. 20	Rabbit	72			14	14	11	2									41
Sept. 8	Rabbit	150					9	4	26	5	30	21	15				110
Sept. 8	Rabbit	150							4	7	1	6	1				19
Sept. 8	Rabbit	150			1	4	37	5	33	3	15	1	6				105
Sept. 27	White rat	10															0
1938																	
May 30	Rabbit	329	6	43	79	68	39	21	8								264
1940																	
Mar. 20	Rabbit	527		13	12	6	1		1	3	1		2	1		1	41
Total		1,688	6	56	160	138	133	58	82	27	50	34	24	1		1	770

temperature of 86.2° F., 10 days at 83.0°, 11 days at 84.5°, 13 days at 83.4°, and 15 days at 79.7°; at heated room temperatures in January and February, 19 days at an average temperature of 78.4°, 20 days at 78.4°, and 20 days at 78.3°; at incubator temperatures of 80° and 90° in December, 10 days. Eleven other lots on which the records were not exact to the day fell within this range, but one lot kept in a heated room in November and December showed an incubation period of 23 to 29 days.

THE LARVA

Observations were made on 22 lots of larvae kept in glass vials at various temperatures. Unfed larvae were short lived, all individuals in some lots dying within two months and none living longer than five months. They were able to engorge satisfactorily when as much as 63 days old, and fed readily on guinea pigs and rabbits, but not on a white rat. Engorgement records on 770 individuals are presented in Table I. The larvae remain attached to the host for several days, the

average time required for those tabulated being 9.2 days, with the greatest number dropping on the seventh day. A few completed engorgement in five days, and one remained attached for 18 days. The measurements of 22 fully engorged larvae in the antero-posterior, lateral, and dorso-ventral dimensions, respectively, ranged from 3.2

TABLE II

RECORD OF LARVAE OF *Ornithodoros coriaceus* MOLTING TO FIRST-STAGE NYMPHS

DATE DROPPED	NUMBER OF LARVAE	NUMBER OF LARVAE THAT MOLTED ON THE SPECIFIED DAY AFTER DROPPING																		
		4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Total
1934																					
Oct. 18	2					1															1
Oct. 30	7[3]		2																		2
Oct. 31	4								2												2
Oct. 31	4[3]	3																			3
Nov. 1	4[3]	2																			2
Nov. 1	4										3					1					4
Nov. 2	2								2												2
Dec. 18	2[3]	1	1																		2
Dec. 22	4[3]	1	2	1																	4
Dec. 23	1[3]		1																		1
Dec. 24	2[3]	1																			1
Dec. 25	6[3]			5						1											6
Dec. 26	2[3]	2																			2
Dec. 27	3[3]	1	2																		3
Dec. 28	1[3]			1																	1
1935																					
Feb. 1	2			2																	2
Feb. 2	1			1																	1
Aug. 27	53					7	16	10	6	2	5	3	2	1	1						53
Aug. 28	38					1	7	16	2	6	4	1								1	38
Aug. 29	33				2	1	1	2	14	2	2	2	2	1			1		2		32
Aug. 30	5								1	1	3										5
1938																					
June 4	21									6	10	3	1								20
June 5	64								12	31	5	7	1								56
June 6	98							4	40	17	17	1									79
June 7	80					2	1	13	21	32	2	1									72
June 8	52							3	31	6	1										41
June 9	33					2	6	10	5	2											25
June 10	12						1	6	5												12
July 5	32			1	17	8	3														29
July 6	82			1	13	33	6	3	5												61
July 7	54				1	1	6	1	6	1											16
July 8	23			1	1	1	3	2	1												9
July 9	15				1	1	4	1													7
Total	746	11	8	13	35	58	54	71	153	107	52	18	6	2	1	1	1		2	1	594

[3]Kept in incubator at 81-90° F. All other lots kept at room temperature, heated in winter.

by 2.0 by 1.5 mm. to 4.3 by 3.0 by 2.0 mm., the average being 4.1 by 2.6 by 1.7 mm.

A few days after engorging, the larvae molt to nymphs, the time required for this change being influenced to a considerable extent by the temperature. Molting records on 594 larvae are presented in Table II.

Some individuals kept at the higher temperatures molted within four days after dropping from the host, while one at normal August and September temperatures required 22 days. The molting of a single lot of 33 larvae, all dropped on the same day and kept under the same conditions of temperature and humidity, was spread over 15 days, two individuals molting as early as the seventh day and two as late as the twenty-first. It will be noted that this is a much greater variation than that between the first moltings in lots kept at different temperatures. The greatest number of larvae molted on the eleventh day, and the average for the 594 was 10.7 days.

THE FIRST-STAGE NYMPH

In common with the other species of its genus, *Ornithodoros coriaceus* goes through several nymphal stages, feeding and molting repeatedly before becoming adult. The number of nymphal stages was found to range from three to seven, one more than required by Herms.

Nymphs in the first stage ordinarily do not feed, but molt to the second stage without engorgement. There is accordingly no increase in size in this stage. Daily molting records were obtained from nymphs kept in pill boxes on dry or moist sand, at room temperature or in an incubator at 81 to 90° F. The molting period of nine nymphs at the incubator temperature ranged from 11 to 27 days, with an average of 15.9 days. The molting period of 125 nymphs at heated room temperature from September to February ranged from 18 to 151 days, with an average of 37.9 days. The molting period ranged from 18 to 19 days for eight nymphs, from 20 to 29 days for 66 nymphs, from 30 to 39 days for 33 nymphs, from 40 to 49 days for four nymphs, and from 108 to 151 days for 14 nymphs.

No nymphs molted between the 49th and 108th days. A typical lot of 11 specimens spread over almost the entire range, their individual molting periods being 18, 19, 27, 27, 28, 28, 28, 30, 30, 31, and 120 days, respectively, although all were kept under identical conditions of temperature and humidity.

On 32 occasions one or more nymphs that were two to eight months old and had not yet molted were placed on hosts, to see if these stragglers would take a meal to hasten development. Three specimens attached, but only two became fully engorged, one requiring 70 and the other 80 minutes. Both were about four months old at the time of feeding. One molted 25 days later and the other 43 days later.

THE SECOND-STAGE NYMPH

The second-stage nymphs invariably feed before molting, but remain attached to the host for a comparatively short time. In these studies they were fed on rabbits and guinea pigs, to which they usually attached readily. Some individuals, however, went through long periods of fasting, during which they repeatedly refused a host, before they were finally ready to engorge. Fasting, engorgement, molting, and other records were obtained on 137 individuals by daily observations. Selected typical and extreme records are presented in Table III, but in the following discussion the records of all 137 are summarized.

Forty-three individuals, or 31 per cent of the entire number, consistently refused to feed until the time of their death, one of them rejecting five opportunities over a period of 314 days. Thirty-two individuals, or 23 per cent, refused to feed one, two, three, or four times

TABLE III

ENGORGEMENT, MOLTING, AND LONGEVITY OF SECOND-STAGE NYMPHS OF *Ornithodoros coriaceus*

Molted From 1st Stage	Refused to Feed	Engorged	Molted to 3rd Stage	Noted Dead	Period From Feeding to Molting (Days)	Duration of Stage (Days)	Feeding Period (Min.)	Size when Engorged (mm.)
11-17-34[4]	.....	12-6-34	1-15-35	.....	40	59	20	.....
1- 3-35	5-21-35.....	6- 3-35	6-27-35	.....	24	175	19	.....
1-17-35[4]	.....	6- 3-35	6-19-35	.....	16	153	30	.....
1-22-35	8-21-35.....	5-21-35	.....	12- 5-35	.....	211[6]	32	.....
1-22-35	.....	5-21-35	9-20-35	.....	122	.....	66[5]	.....
		8-21-35	.....	.....	30	241	91[5]	4.9 x 2.9 x 2.1
1-26-35[4]	.....	5-21-35	6- 5-35	.....	15	130	19[5]	.....
9-21-35	12-3-35.....	.....	.....	2-17-36	.....	73[6]	.....	.....
9-22-35	10-25-35;11-20-35; 12-9-35.....	2-17-36	3-14-36	.....	26	174	61[5]	.....
9-22-35	10-25-35;11-20-35	12- 9-35	1- 4-36	.....	26	104	68[5]	.....
9-23-35	10-25-35;11-20-35; 12-9-35; 2-17-36..	3-18-36	.....	8- 5-36	.....	177[6]	20	.....
		10-25-35	.....	.....	72	.....	33	4.8 x 2.9 x 2.3
9-24-35	11-20-35.....	12- 9-35	1- 5-36	.....	27	103	129[5]	.....
9-25-35	10-25-35;11-20-35	12- 9-35	12-28-35	.....	19	94	122[5]	.....
9-25-35	11-20-35; 8-5-36..	.....	.....	11-12-36	.....	315[6]	.....	.....
9-26-35	10-25-35;11-20-35; 2-17-36;3-18-36; 8-5-36.....	.....	.....	11-12-36	.....	314[6]	.....	.....
9-29-35	11-20-35.....	3-18-36	7- 2-36	.....	106	277	15	.....
10- 1-35	11-20-35.....	.....	.....	8- 5-36	.....	50[6]	.....	.....
10- 2-35	.....	12- 2-35	1- 3-36	.....	32	93	30	6.8 x 4.0 x 3.4
10- 3-35	.....	12- 3-35	1- 2-36	.....	30	91	24	6.6 x 4.0 x 3.0
10- 3-35	12-3-35.....	7-29-36	9-11-36	.....	44	344	22	6.0 x 3.9 x 3.4
10- 5-35	.....	12- 3-35	.....	7-26-36	.....	59[6]	17	6.5 x 3.9 x 3.0
10- 6-35	12-3-35.....	7-29-36	8-24-36	.....	26	323	42	5.6 x 3.5 x 3.2
10- 9-35	12-3-35; 2-17-36..	7-29-36	10- 9-36	.....	72	366	30	5.4 x 3.2 x 2.8
10- 9-35	.....	12- 3-35	1- 6-36	.....	34	89	63[5]	7.1 x 4.2 x 3.3
10-10-35	12-3-35.....	2-17-36	3-23-36	.....	35	165	22	6.3 x 3.8 x 3.1
10-15-35	12-5-35; 2-17-36..	7-29-36	9- 1-36	.....	34	322	47	4.9 x 3.0 x 2.5
10-22-35	.....	12- 5-35	1- 7-36	.....	33	77	68[5]	6.4 x 3.9 x 3.0
10-29-35	.....	12- 5-35	1-13-36	.....	39	76	57[5]	6.5 x 3.6 x 3.0
12-29-35	2-17-36; 3-18-36..	7-29-36	10-14-36	.....	77	290	23	5.9 x 4.8 x 3.0
1- 2-36	3-18-36.....	7-29-36	9-16-36	.....	49	258	30	6.2 x 3.7 x 3.2
1-21-36	.....	3-26-36	.....	.....	149	.....	103[5]	.....
		7-27-36	8-22-36	.....	26	214	16	.....

[4]Kept in cabinet at 81-90° F., all others kept at room temperature, heated in winter.
[5]Picked from host.
[6]At least this long; see text.

before they finally accepted a meal when placed on a host. Thirty of those that had refused to feed one or more times before engorging molted successfully, only two dying before reaching the third stage, showing that refusal of a host did not indicate an abnormality. Three of the 62 that engorged at the first opportunity died before molting.

Eighty-five specimens engorged only once, and three engorged twice, before molting to the next stage. Hosts were accepted in from 19 to 301 days after the tick had molted from the previous stage. The ticks became fully engorged and dropped in from 8 to 155 minutes. Many specimens became fully engorged in a short time but instead of dropping at once remained attached to the host and began to secrete coxal fluid and to lose size. When it became apparent that these had completed feeding but would not or could not drop normally, they were picked off, as indicated in the table. The size of 29 second-stage nymphs when fully engorged ranged from 7.1 by 4.2 by 3.3 mm. to 4.8 by 2.9 by 2.3 mm., with an average of 5.9 by 3.6 by 2.9 mm.

Among ticks that fed only once, molting to the third nymphal stage occurred in from 15 to 106 days after feeding. One of the ticks that fed twice did not molt for 149 days after the first meal and 26 days after the second.

The total duration of the second nymphal stage, in individuals that molted, ranged from 59 to 366 days. As the ticks that fail to molt approach death they become sluggish and are difficult to stimulate, so that it is almost impossible to determine whether they are actually dead until they become dry and brittle. For this reason, in this and the following tables, the date under "Noted dead" is well after death actually occurred, and records of the time spent in the stage are therefore calculated from the last living observation as noted in the second or third column. Estimated by this method, the duration of the second stage of ticks that did not feed ranged from over 50 to over 315 days, whereas that of ticks that fed but did not molt ranged from over 59 to over 211 days.

THE THIRD-STAGE NYMPH

The behavior of the third-stage nymphs is very similar to that of nymphs in the second stage with respect to the feeding period, refusal of hosts, longevity, and molting. Records were obtained on 80 individuals by daily observation. Selected typical and extreme examples are presented in Table IV, but in the following discussion the records of all 80 are summarized. Twenty-five individuals, or 31 per cent, consistently refused to feed throughout their lives, rejecting from one to five opportunities over periods of as much as 340 days. Eighteen individuals, or 23 per cent, refused to feed once or twice before taking a host. One of these refused to feed nine times, but engorged twice, during a period of three years and 11 months, after which it died without molting. Thirty-seven ticks, or 46 per cent, engorged at the first opportunity.

Engorgement occurred satisfactorily when nymphs had been in the third stage for as short a time as nine days, and as long as two years, but the individual making the latter record did not molt. Two individuals that engorged one year and six weeks after molting from second-stage nymphs molted successfully to the next stage. Most of the nymphs would accept only one meal, but some fed two or three times. Complete engorgement and dropping from the host required from 5 to 62 minutes, but some individuals did not drop and had to be picked off. Measurements of 37 nymphs fully engorged ranged

from 6.5 by 4.0 by 3.0 mm. to 9.9 by 6.4 by 5.1 mm., with an average of 7.8 by 4.8 by 3.9 mm. Only one of the specimens that fed more

TABLE IV

ENGORGEMENT, MOLTING, AND LONGEVITY OF THIRD-STAGE NYMPHS OF *Ornithodoros coriaceus*

Molted From 2nd Stage	Refused to Feed	Engorged	Molted to 4th Stage or Adult	Noted Dead	Period From Feeding to Molting (Days)	Duration of Stage (Days)	Feeding Period (Min.)	Size when Engorged (mm.)
12-31-34[7]	.....	5-21-35	6- 6-35	.....	16	157	60[8]	.....
6-17-35	8-21-35.....	10-25-35	.....	.....	101	.....	100[8]	.....
		12- 9-35	2- 3-36	.....	56	231	24	.....
6-27-35	8-21-35.....	7- 6-35	8-26-35	.....	51	60	19	.....
12-28-35	.....	2-17-36	3-26-36	.....	38	89	40	9.5 x 5.9 x 5.1
12-30-35	2-17-36.....	3-18-36	5-18-36	.....	61	140	62	7.1 x 4.5 x 3.7
12-31-35	3-18-36.....	7-29-36	9-16-36♂	.....	49	260	13	8.4 x 5.2 x 4.3
1- 1-36	3-18-36.....	.....	.....	7-29-36	.....	77	.....	.....
1- 2-36	3-18-36; 7-29-36; 12-7-36.....	.....	.....	1-10-37	.....	340	.....	.....
1- 5-36	3-26-36; 1-7-37;	7-27-36	.....	.....	270	.....	24	8.4 x 5.0 x 4.3
	4-6-37.....	12- 3-36	.....	.....	141	.....	17	.....
		2-23-37	4-23-37♂	.....	59	474	13	.....
1- 5-36	3-26-36; 7-27-36..	12- 7-36	1- 7-37	.....	31	368	22	7.6 x 3.7 x 3.0
1- 5-36	.....	3-26-36	6- 4-36	.....	70	151	14	8.0 x 5.0 x 4.2
1- 6-36	3-26-36.....	7-27-36	9-11-36♀	.....	46	249	21	9.9 x 6.4 x 5.1
1- 7-36	.....	3-26-36	.....	.....	185	.....	23	9.2 x 5.7 x 4.5
		7-27-36	9-27-36	.....	62	264	19	8.8 x 5.4 x 4.9
1- 8-36	3-26-36.....	7-27-36	9-16-36♂	.....	51	252	30	8.1 x 5.1 x 4.0
1- 9-36	7-27-36.....	3-26-36	8-10-36	.....	137	214	23	8.9 x 5.8 x 4.5
1-15-36	.....	3-26-36	5- 8-36	.....	43	114	10	6.5 x 4.0 x 3.0
1-21-36	.....	3-26-36	4-20-36	.....	25	90	17	8.0 x 5.2 x 4.1
1-31-36	12-3-36; 1-10-37	.....	.....	.....	.....	.....	.....	.....
	2-23-37; 5-31-37	8- 6-36	.....	.....	.....	.....	28	.....
	11-26-37; 1-30-40	2-15-38	.....	4-18-40	.....	1,460	8	.....
2-23-36	8-6-36; 12-7-36;	1-10-37	.....	.....	120	.....	14	7.2 x 4.6 x 3.9
	1-23-37.....	4- 6-37	5-10-37♂	.....	34	442	15	.....
4-26-36	.....	8- 6-36	9-11-36♀	.....	36	138	28	.....
5-13-36	5-6-36; 11-22-36	1- 7-37	.....	.....	.....	.....	27	.....
	2-23-37; 4-6-37;							
	5-31-37; 11-26-37	2-15-38	.....	.....	.....	.....	11	.....
	9-15-39; 1-30-40;							
	4-19-40.....	.....	.....	6-24-40	.....	1,437	.....	.....
6- 6-36	.....	8-10-36	9-18-36	.....	39	104	5	7.5 x 4.7 x 3.7
8-24-36	.....	11-22-36	.....	.....	74	.....	14	7.5 x 4.6 x 3.7
		1- 7-37	2- 4-37	.....	28	164	7	8.0 x 4.4 x 3.4
9-11-36	11-22-36;1-10-37;							
	2-23-37; 4-6-37;							
	5-31-37.....	.....	.....	11-26-37	.....	262	.....	.....
10- 9-36	11-22-36.....	.....	.....	1- 7-37	.....	44	.....	.....

[7]Kept in cabinet at 81–90° F., all others kept at room temperature, heated in winter.
[8]Picked from host. ♂ Molted to male. ♀ Molted to female.

than once was measured after each meal, and it was smaller after the second feeding.

Molting occurred as soon as 16 days and as late as 137 days after feeding in the case of ticks that fed only once and as long as 270 days after the first meal in the case of one individual that engorged three

times. Of the 52 specimens that molted, 42 produced fourth-stage nymphs, eight produced males, and two produced females.

The total duration of the third nymphal stage in specimens that molted ranged from 60 to 474 days. The time spent in the third stage by specimens that never fed ranged from about 44 days to more than 340 days and that of specimens that fed one or more times but never molted reached a maximum of more than four years.

THE FOURTH-STAGE NYMPH

The behavior of fourth-stage nymphs was similar, in all respects, to that of nymphs in the third stage. Records were obtained on 42 individuals by daily observations. Selected typical and extreme examples are presented in Table V, but in the following discussion the records of all 42 are summarized. Fourteen individuals never fed, refusing from one to eight opportunities to attach during periods of as long as 23 months. Eleven specimens refused to feed one to five times before engorging, and 17 fed at the first opportunity.

Engorgement occurred as soon as 14 days and as late as five years and five months after the nymph had molted from the previous stage. Nymphs that molted to the next stage engorged from one to three times. One tick which was still alive at the time of writing had engorged six times. Complete engorgement required from 7 to 43 minutes of feeding. The size of 17 fourth-stage nymphs when fully engorged ranged from 6.1 to 4.0 by 3.5 mm. to 12.8 by 7.9 by 6.5 mm., with an average of 9.0 by 5.7 by 4.5 mm.

Molting occurred in 19 to 131 days after engorgement, 13 specimens molting to fifth-stage nymphs, two molting to males, and seven molting to females.

The total duration of the stage in the case of those that molted ranged from 39 days to 16 months. The time spent in the stage by ticks that never fed ranged from about 46 days to more than 23 months. Ticks that fed but did not molt lived as long as five years and five months.

NYMPHS OF THE FIFTH, SIXTH, AND SEVENTH STAGES

The behavior of nymphs in the fifth, sixth, and seventh stages was similar, in all respects, to that of nymphs in the fourth stage. Records on nymphs in these stages are presented in Table VI. Three of the 13 fifth-stage nymphs and 2 of the 4 sixth-stage nymphs consistently refused to feed during the course of from 3 to 26 months. One fifth-stage nymph fed three times in five years and five months and was still alive and unmolted at the time of writing.

All other nymphs engorged once and molted successfully. The size of four fifth-stage nymphs when fully engorged ranged from 7.9 by 4.9 by 3.4 mm. to 11.9 by 7.9 by 5.9 mm., with an average of 9.5 by 6.1 by 4.5 mm. The size of one sixth-stage nymph was 9.0 by 6.0 by 4.2 mm. and that of one seventh-stage nymph was 10.6 by 6.5 by 5.3 mm.

The period from last feeding to molting ranged from 27 to 110 days in the fifth stage, the nine nymphs that molted producing four nymphs, two males, and three females. Two sixth-stage nymphs molted in 44 days and 72 to 89 days, respectively, after feeding, producing one

nymph and one female. The seventh-stage nymph molted in 45 days to a female.

TABLE V

ENGORGEMENT, MOLTING, AND LONGEVITY OF FOURTH-STAGE NYMPHS OF *Ornithodoros coriaceus*

Molted From 3rd Stage	Refused to Feed	Engorged	Molted to 5th Stage or Adult	Noted Dead	Period From Feeding to Molting (Days)	Duration of Stage (Days)	Feeding Period (Min.)	Size when Engorged (mm.)
6- 6-35[9]	.....	6-26-35	7-15-35	.....	19	39	43	.....
6-24-35	8-21-35.....	7- 8-35	8-24-35	.....	47	61	41	.....
7-14-35[9]	.....	8-21-35	9-11-35	.....	21	59	22	6.1 x 4.0 x 3.5
8-26-35	10-25-35; 12-9-35	.....	.....	8- 5-36	.....	105[11]	.....	.....
10-20-35	12-5-35.....	.....	.....	2-17-36	.....	46[12]	.....	.....
12-27-35	.....	2-17-36	3-14-36	.....	26	78	18	.....
1- 4-36	.....	3-18-36	7-27-36	.....	131	205	28	7.9 x 5.4 x 4.0
1-10-36	3-26-36; 7-27-36	12- 7-36	.....	.....	112	.....	16	.....
		1-10-37	.....	.....	78	.....	5[10]	.....
		2-23-37	3-29-37	.....	34	444	.....	.....
2-10-36	8-6-36; 12-7-36...	.....	.....	1-10-37	.....	301[12]	.....	.....
3-26-36	8-6-36; 12-3-36; 1-10-37; 2-23-37; 4-6-37; 5-31-37; 11-26-37; 2-15-38	.....	.....	5-19-38	.....	691[12]	.....	.....
4-20-36	.....	8- 6-36	9- 8-36♀	.....	33	141	39	11.9 x 7.6 x 6.3
4-22-36	8-6-36; 12-3-36; 1-10-37; 4-6-37..	2-23-37	4-30-37	.....	66	373	15	8.5 x 5.7 x 4.4
4-26-36	.....	8-6-36	9-12-36♀	.....	37	139	34	12.5 x 8.0 x 6.4
5- 8-36	.....	8- 6-36	9-16-36♀	.....	41	131	30	9.3 x 5.6 x 4.7
5-11-36	1-10-37; 2-23-37; 5-31-37; 11-26-37; 9-15-39; 4-19-40	8- 6-36	.....	.....	.....	.....	17	8.3 x 5.2 x 3.8
		11-22-36	.....	.....	.....	.....	5[10]	.....
		4- 6-37	.....	.....	.....	.....	15	.....
		2-15-38	.....	.....	.....	.....	8	.....
		1-30-40	.....	.....	.....	.....	.....	.....
		10-17-41	.....	.....	.....	1,988[11]	7	.....
5-13-36	.....	8-6-36	9- 8-36♀	.....	33	118	27	12.8 x 7.9 x 6.5
5-19-36	11-22-36; 2-23-37; 5-1-37; 11-26-37; 2-15-38.....	8-10-36	.....	.....	.....	.....	16	7.5 x 4.5 x 3.2
		1-10-37	.....	.....	.....	.....	7	7.5 x 4.3 x 3.2
		4- 6-37	.....	10-19-39	.....	637[12]	4[10]	.....
5-25-36	.....	8-10-36	9-13-36	.....	34	111	32	9.4 x 5.8 x 4.7
7- 5-36	.....	8-10-36	9-17-36♀	.....	38	74	23	9.5 x 6.0 x 4.8
8-10-36	11-22-36; 1-7-37; 2-23-37; 4-6-37; 5-31-37.....	2-15-38	.....	5-19-38	.....	554[12]	14	.....
9-18-36	1-7-37; 2-23-37...	11-22-36	3-20-37	.....	118	183	21	9.0 x 5.6 x 4.0
9-29-36	11-22-36.....	.....	.....	1- 7-37	.....	54[12]	.....	.....
10- 7-36	11-22-36; 1-7-37; 2-23-37; 4-6-37..	.....	.....	5-31-37	.....	181[12]	.....	.....
1- 7-37	5-31-37; 11-26-37	2-15-38	5-19-38♂	.....	93	497	33	.....
2- 1-37	.....	5-31-37	7-11-37♂	.....	41	160	22	.....

[9]Kept in cabinet at 81-90° F., all others kept at room temperature, heated in winter.
♂ Molted to male. ♀ Molted to female.
[10]Incompletely engorged.
[11]Alive October 20, 1941.
[12]At least this long.

The duration of the fifth, sixth, and seventh stages in the case of ticks that molted was 64 to 401 days, 139 to 265 days, and about 100

days, respectively. The known longevity of unfed ticks was 83, 218, and 781 days in the fifth stage and 79 to 81 days in the sixth. A fifth-stage nymph which fed but did not molt was still alive at the time of writing, after 1,911 days.

TABLE VI

ENGORGEMENT, MOLTING, AND LONGEVITY OF FIFTH-, SIXTH-, AND SEVENTH-STAGE NYMPHS OF *Ornithodoros coriaceus*

Molted From Former Stage	Refused to Feed	Engorged	Molted to Next Stage	Noted Dead	Period From Feeding to Molting (Days)	Duration of Stage (Days)	Feeding Period (Min.)	Size when Engorged (mm.)
			FIFTH-STAGE NYMPHS					
7-15-35[13]	.....	8-21-35	9-17-35	.....	27	64	120[14]	7.9 x 4.9 x 3.4
8-24-35	10-25-35.....	12- 9-35	1-19-36	.....	41	148	13	.....
9-11-35[13]	10-25-35.....	12- 5-35	1- 2-36	.....	28	113	10	.....
9-13-35[13]	10-25-35; 12-5-35	.....	.....	8-10-36	.....	83	.....	.....
3-14-36	.....	8- 6-36	9-16-36♂	.....	41	186	23	.....
7-27-36	11-22-36; 1-10-37	8-10-36	.....	.....	.....	.....	37	8.0 x 4.8 x 3.5
	2-23-37; 4-6-37	2-15-38	.....	.....	.....	.....	22	.....
	5-31-37; 11-26-37	1-30-40	.....	.....	.....	.....	.....	.....
	9-15-39; 4-19-40; 10-17-41.....	.....	.....	.....	.....	1,911[15]	.....	.....
9-13-36	11-22-36; 1-7-37..	2-23-37	4- 3-37♀	.....	39	202	12	10.0 x 6.8 x 5.3
2-25-37	.....	5-31-37	7-13-37♀	.....	43	138	26	.....
3-29-37	.....	5-31-37	7-21, 11-26-37♂	.....	51-179	114-242	82[14]	.....
4- 3-37	.....	5-31-37	7-21, 11-26-37	.....	51-179	109-237	37	11.9 x 7.9 x 5.9
4-30-37	5-31-37; 11-26-37	2-15-38	6- 5-38♀	.....	110	401	30	.....
7-12-37	11-26-37; 2-15-38	.....	.....	10-19-39	.....	218[16]	.....	.....
2-24-38	1-30-40; 4-15-40..	.....	.....	6-24-40	.....	781[16]	.....	.....
			SIXTH-STAGE NYMPHS					
9-17-35[13]	10-25-35; 12-5-35	.....	.....	8-10-36	.....	79[16]	.....	.....
1- 2-36	.....	8-10-36	9-23-36♀	.....	44	265	19	.....
1-19-36	.....	3-26-36	6-6-23-36	.....	72-89	139-156	40	9.0 x 6.0 x 4.2
7-21-11-26-37	11-26-37; 2-15-38	.....	.....	10-19-39	.....	81[16]	.....	.....
			SEVENTH-STAGE NYMPH					
6- 6-23-36	.....	8-10-36	9-24-36♀	.....	45	93-110	36	10.6 x 6.5 x 5.3

[13]Kept in cabinet at 81-90° F., all others kept at room temperature, heated in winter.
[14]Picked from host. ♂ Molted to male. ♀ Molted to female.
[15]Alive October 20, 1941.
[16]At least this long.

THE ADULT

Records were obtained on the feeding, mating, oviposition, and longevity of 4 males and 17 females collected in nature and of 18 males and 14 females reared from nymphs. Although the records were kept on each tick as an individual, a female might be placed with several males in succession, or vice versa. These records are not adaptable to tabular presentation, but will be briefly discussed.

The feeding habits of adult males and females are very similar to those of nymphs. Males attached and engorged as soon as six weeks and as late as 17 months after they had molted. Females engorged as soon as 26 days and as late as three years and four months after they had molted. Both sexes fed and refused feedings repeatedly throughout their adult lives, some engorging as many as five times. Engorgement required from 10 to 34 minutes in the case of males and from 5 to 51 minutes in the case of females.

Mating took place off the host after one or more feedings by both sexes. Only 15 matings were actually observed, and no male or female was seen to mate twice, but mating might easily have been overlooked. Observed matings took place in from one day to three months after the last feeding by both sexes.

Oviposition followed observed mating by from two weeks to seven months.

Reared females began ovipositing four to six months after the first feeding. When two meals were taken before the first oviposition, the females began ovipositing 18 to 106 days after the second meal. The first oviposition was followed by other feedings, and these in turn were followed by other periods of oviposition after eight days to nine months. Individual females laid as many as three lots of eggs, with intervening feedings. Sometimes the entire lot was deposited in a single day and sometimes spread over as many as eight days. The greatest number of eggs deposited in a single lot was 710, and the greatest number deposited by a single female was 1,424, and this female was still alive at the time of writing. Only four reared females oviposited, each laying two or three lots of eggs, the counts of which were 165 and 28, 221 and 337, 161 and 259, and 527, 187, and 710, respectively.

The adult longevity of reared, fed ticks ranged from about eight months to more than three years and seven months for males and from 13 months to more than five years in the case of a female still alive at the time of writing. The longest adult life span of ticks that never fed was about nine months for both male and females. The corresponding records for collected specimens were naturally shorter. The longest interval between feedings was one year and seven months in the case of collected females, one year and 11 months in the case of reared females, and one year in the case of both collected and reared males.

LITERATURE CITED

(1) **Herms, William B.** 1916. The pajaroello tick (*Ornithodoros coriaceus* Koch) with special reference to life history and biting habits. J. Parasitol. 2: 137–142, illus.

(2) **Hoffmann, C. C.** 1930. Monografias para la entomologia medica de Mexico, Monografia Num. 1, Los Argasidos de Mexico. An. Inst. Biol. Univ. Nacional Autonoma (Mex.) 1: (135)–164, illus.

(3) **Koch, C. L.** 1844. Systematische Übersicht über die Ordnung der Zecken. Arch. f. Naturg., Berlin, 10: 217–239.

(4) **Nuttall, George H. F., Cecil Warburton, W. F. Cooper,** and **L. E. Robinson.** 1908. Ticks. A monograph of the Ixodoidea. Part 1. Argasidae. Cambridge University Press, London, 104 pp., illus.

(5) **True, Gordon H., Jr.** 1932. Studies of the anatomy of the pajaroello tick, *Ornithodorus coriaceus* Koch. 1. The alimentary canal. Univ. Cal. Pub. Ent. 6: 21–48, illus.

A COMPARATIVE STUDY OF THE APPENDAGES OF THE EIGHTH AND NINTH ABDOMINAL SEGMENTS OF INSECTS

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This is a preliminary paper intended to establish the interordinal homologies of the genital appendages of insects more accurately and with greater certainty than has been possible in the past. Much additional work on the subject is desirable in practically all of the orders of insects. While this paper was intended primarily as a study of the male genitalia, it has been found necessary to consider first the structures of the ovipositor of female insects. Here the homologies appear to be relatively easily understood, and with the exception of one or two points, most authors agree in their interpretation of them. Except where it seems advisable to use other names, the terminology employed by Snodgrass (1935) has been followed in this paper.

FEMALES

The ovipositor consists of the appendages of the eighth and ninth abdominal segments. In the Apterygota such appendages apparently occur only in the Machilidae and Lepismidae. As shown in figure 3, each of these appendages in *Machilis* consists of a broad, flattened coxopodite produced at the base of its inner margin as an endite or gonapophysis and bearing at its apex a musculated stylus. The styli probably represent the telopodites of these appendages. (The similarly shaped but nonmusculated "styli" born on the coxae of the rear thoracic legs in *Machilis* are apparently not homologous to the abdominal styli.) The broad basal plates may be known as coxites since each is only a part of the coxopodite, the other part being the gonapophysis.

In *Thermobia* (fig. 4) the situation is similar except that a small basal portion of each coxite of the ninth abdominal segment becomes separated from the rest while retaining its attachment to the gonapophysis.

From such a structure it is a simple step to the ovipositor of a pterygotan insect [e.g., Odonata, Hemiptera, Homoptera, Hymenoptera (figs. 5 and 6)]. The coxites of the eighth and ninth segments become the first and second valvifers respectively, while the gonapophyses become the first and second valvulae. The third valvulae are the styli of the ninth segment, those of the eighth having disappeared. In the orthopteroid groups (including Grylloblattoidea, Phasmoidea, Man-

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toidea, and Blattoidea) these styli disappear in the adults, as is stated by Walker (1919) and clearly shown in his figures. It is for this reason that Snodgrass (1935) believed styli to be absent from the ovipositors of most Pterygota. His third valvulae of Orthoptera are merely subdivisions of the second valvifers. It therefore seems reasonable to term the third valvulae of orders other than the orthopteroid groups the gonostyli. The Hymenoptera differ from other orders in exhibiting a secondary point of articulation between the first valvifer and the tenth tergum (fig. 6).

MALES

The copulatory organs of male insects are highly variable. In some the cerci or processes of the eighth, ninth, or tenth abdominal segments are evidently secondarily modified for copulatory purposes. However, in addition to the penis, the copulatory organs of the majority of male insects are certain musculated claspers, attached at least in the adult to the ventral or lateral portions of the ninth abdominal segment. It is the homologies of these *primary copulatory organs* with which we are here concerned.

These homologies have been subject to much difference of opinion, some workers having suggested that in certain orders these organs are all phallic structures which have arisen *de novo* in insects; others, that at least some of them are true appendicular structures. Appendages of the eighth, ninth, and tenth abdominal segments have been regarded by various authors as contributing parts to the male primary copulatory apparatus. Some have believed that the claspers consist largely of styloid structures comparable to the coxal processes of certain Thysanura. Others suggest that the endopodite and exopodite of primitive biramous appendages form the inner and outer claspers respectively. Many workers who believe in the appendicular origin of the claspers regard telopodite derivatives as contributing to them, while a few believe that except for the lower orders of insects, only coxopodite derivatives are present.

Some authors (e.g., Crampton, 1919, 1920a; Newell, 1918) have attempted to homologize the parts of the genitalia through many orders of insects while others (e.g., Snodgrass, 1935) have believed that the claspers in some groups were entirely different in origin from those in others. Thus the outer claspers of Hymenoptera were regarded as phallic structures, while the at least functionally similar claspers of Diptera and Lepidoptera were regarded as periphallic organs, modifications of walking appendages.

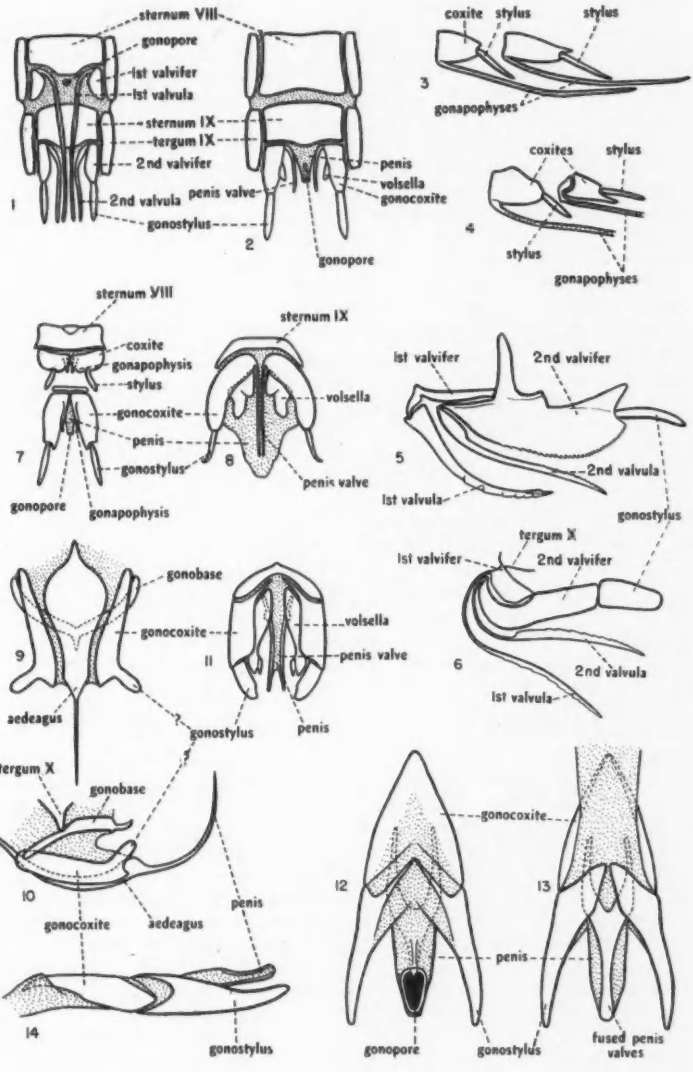
Ontogeny: In view of the differences of opinion, it seems necessary first to establish with certainty the segment with which the primary copulatory structures are associated. Apparently the most important evidence is the fact that, as already stated, in the adults they are always articulated on the ninth abdominal segment or lie immediately behind that segment. Since the embryonic appendages of the tenth abdominal segment are retained as larval "legs" or postpedes in many holometabolous insects (Johannsen and Butt, 1941), and since the rudiments of the copulatory structures arise in the larva while these legs are still present, we may be quite certain, as pointed out by Snod-

grass (1941) that tenth segment appendages do not enter into the formation of the genitalia in these forms, although, as shown by Else (1934) and Qadri (1940) they appear to do so in Orthoptera. Holometabolous insect larvae, however, do not have "legs" on the ninth abdominal segment, which is the segment upon which the claspers are situated, or if appendages are present as in the larvae of Trichoptera, they give rise to claspers (Crampton, 1920, 1920a). It seems certain, then, that at least the outer claspers, and the inner ones as well except possibly in the Orthoptera, are, like the gonopore, associated with the ninth abdominal segment.

The most important evidence concerning the nature of the male copulatory structures is obtained from a comparative study through the orders of insects. It seems desirable, however, to present first certain other facts which support the homologies indicated by the comparisons. That the copulatory organs are new structures (probably of phallic origin) seems far less probable than that they are derived from pre-existing structures. In this connection I quote from the excellent statement of principles suggested by Ferris (in Ferris and Rees, 1939) as a guide for morphological work: "The introduction of completely new elements as contrasted with the other means of modification which have been indicated, will be comparatively, or even absolutely, rare. Consequently recourse to the assumption that a completely new structure has appeared should be had only as a last resort in attempting to elucidate an obscure situation." Evidence for the phallic origin of the primary copulatory structures appears to be based primarily on developmental history, the lobes of immature forms which become the genital apparatus of adults not appearing to belong to the same dynamic series as the true appendages, but often arising late in ontogeny and near the position of the developing gonopore. However, the undoubted appendages which appear, at least in the Thysanura, Orthoptera, etc. (Johannsen and Butt, 1941), early in the embryonic history as lobes of the genital segments disappear in most cases before hatching, so that lobes formed later in ontogeny, even though seemingly in slightly different positions, may nevertheless be redeveloping appendages.

EXPLANATION OF PLATE I

1. Diagrammatic ventral view of hypothetical primitive pterygotan ovipositor and associated structures. (For the sake of clarity, the gonapophyses are illustrated as separated rather than locked together.) 2. Diagrammatic ventral view of the primary copulatory organs and associated structures of a hypothetical primitive male pterygotan insect. 3. Lateral view of appendages of eighth and ninth abdominal segments of female *Machilis* [Thysanura]. 4. Lateral view of appendages of eighth and ninth abdominal segments of female *Thermobia domestica* (Packard) [Thysanura]. 5. Lateral view of ovipositor of *Lestes* sp.? [Odonata]. 6. Lateral view of ovipositor of *Cephus cinctus* Norton [Hymenoptera]. 7. Ventral view of appendages of eighth and ninth abdominal segments of male *Machilis* sp? [Thysanura]. 8. Ventral view of male primary copulatory organs and associated structures of *Agulla* sp? [Neuroptera]. 9 and 10. Ventral and lateral views of male primary copulatory organs of *Climaciella* sp? [Neuroptera]. 11. Ventral view of male primary copulatory organs of *Xiphydria* [Hymenoptera]. 12, 13, and 14. Dorsal, ventral and lateral views of male primary copulatory organs of *Hydrous triangularis* (Say) [Coleoptera].


sternum VIII
gonopore
1st valvifer
1st valvula
sternum IX
tergum IX
2nd valvifer
2nd valvula
penis valve
gonostylus
1
2
penis
volsella
gonocoxite
gonopore
coxite
stylus
stylus
3
gonapophyses
coxites
stylus
4
stylus
gonapophyses
sternum VIII
coxite
gonapophysis
stylus
gonocoxite
penis
gonostylus
7
gonopore
gonapophysis
sternum IX
volsella
8
penis valve
1st valvifer
2nd valvifer
5
2nd valvula
1st valvula
gonostylus
tergum X
1st valvifer
2nd valvifer
6
2nd valvula
1st valvula
gonobase
gonocoxite
9
aedeagus
volsella
11
penis valve
gonostylus
penis
tergum X
gonobase
10
gonocoxite
aedeagus
penis
14
gonostylus
gonocoxite
12
13
penis
gonopore
gonostylus
fused penis valves

A different line of evidence concerning homologies of the claspers involves the subdivisions of the lobes of the immature forms which develop into the copulatory structures. In the Hymenoptera, each of these lobes divides incompletely into processes which later form the inner and outer claspers. In the Trichoptera (Zander, 1901) and Lepidoptera (Zander, 1903) and presumably in the Diptera, Mecoptera, etc., on the other hand, each lobe divides completely and the lateral members migrate outward and come to be the musculated appendages of the ninth somite. Therefore, in opposition to Snodgrass (1935), it appears to me that the claspers are homologous throughout at least the higher orders of insects, the division between the outer and inner pairs being merely less complete in the Hymenoptera than in certain other orders. This evidence is inconclusive, however, since Mehta (1933) claims that the outer claspers of Lepidoptera arise independently from the inner ones and Singh-Pruthi (1924) makes a similar statement with regard to the Homoptera.

Sex Anomalies: In attempting to establish with greater certainty the homologies of the male terminalia, a study of several sex anomalies has been undertaken. Popov (1937) has recorded and figured a stylopized gynandromorphic specimen of *Halictus eurygnathus* Blüthgen in which the genitalia are divided longitudinally, one half being male, the other female. A similarly abnormal individual of *Chalcidoma muraria* (Retzius) is described by Bischoff and Ulrich (1929). In these specimens the outer clasper on the male side corresponds to the combined second valvifer and third valvula or gonostylus of the female, while the inner clasper or penis valve of the male probably corresponds to the second valvulae, although Popov interprets it as corresponding to the combined first and second valvulae. An intersex of *Ashmeadiella rhodognatha* (Cockerell) before me is somewhat more female than male. The first valvula and valvifer are reduced to a single narrow ribbon. The third valvula has become immovably fixed to the second valvifer and the two second valvulae are incompletely fused, modifications which would be expected in such a specimen if the homologies are those indicated by the gynandromorphic bees mentioned above. Gynandromorphic specimens of Tettigoniidae described and figured by Cappe de Baillon (1924, 1932) suggest the same homologies, the first valvulae being absent on the male size, the second valvulae apparently corresponding to the penis valves, and the combined second valvifers and third valvulae corresponding to part of the subgenital plate of the male which, as pointed out below, is a coxosternum consisting of the fused ninth sternum and at least parts of the corresponding coxopodites. An apparently similar gynandromorph in Gryllidae is briefly described by Ohmachi (1926).

It would be unreasonable not to cite in this connection certain records of gynandromorphs whose structure does not support the homologies between male and female parts suggested above. Thus Popov (1935) describes an *Andrena* and Peacock (1924, 1925) two tenthredinids in which male claspers are present in whole or in part in addition to a full complement of female gonopods. Clearly the evidence derived from gynandromorphs is not conclusive, since even within the bees in which the male claspers are undoubtedly homologous from group

to group, certain gynandromorphs suggest homologies between female gonopods and male claspers, while others suggest that the claspers are structures of separate origin from the female ovipositor. However, the intersex referred to, which is probably more reliable for our purposes than gynandromorphic individuals, and gynandromorphs in widely separated groups lend weight to the idea of homologies between the male and female copulatory parts.

Homologies and Terminology: If the homologies suggested by the sexually anomalous *Halictus*, *Chalcidoma*, *Ashmeadiella*, etc., are correct, we can homologize in detail the male and female parts of the appendages of the ninth abdominal segment. The third valvulae or gonostyli of the female become the distal organs of the outer claspers of the male; the second valvifers are sometimes subdivided, their basal portions fusing to form a transverse basal piece or basal ring, their separately movable distal portions, or the structure in its entirety if no basal piece exists, representing the basal segments of the outer claspers; the second valvulae probably become the inner claspers or penis valve, commonly more or less completely separated from the outer claspers.

Approximately these same homologies have been suggested by Singh-Pruthi (1924, 1929), who stated that the outer claspers (his subgenital plates) correspond to the second valvulae (lateral ovipositor valves), the penis and its valves (his aedeagus and parameres) correspond to the third valvulae or gonostyli (dorsal ovipositor valves), while the homologues of the ovipositor valves arising on the eighth segment are absent in most male insects, although present in *Machilis*, a species of *Tipula* (Singh-Pruthi, 1924), etc.

Before presenting the strong comparative morphological evidence for these homologies, it is necessary to define the various terms used in referring to the parts of the male copulatory apparatus. The terminology here used represents an attempt to use, for each structure, a name at least not misleading as to homology and neither used for so many different structures as to be meaningless (as is paramere), nor indicative of a shape not at all constant for the structure involved (as is squama).

Gonopods—In the male, the pair of segmental appendages of the ninth abdominal segment.

Gonocoxopodites—The coxopodites (including gonobase, penis valves, and volsellae) of the gonopods.

Gonocoxites—The gonocoxopodites except for penis valves, volsellae, and gonobase when present. The gonocoxites are the basal segments of the outer claspers.

Gonobase—The fused basal portions of the gonocoxites when the latter are articulated to the gonobase.

Penis valves—Mesal basal processes of the gonocoxopedites which usually serve to support the penis. These are the inner claspers of some insects and frequently become detached from the gonocoxites.

Volsellae—Processes of the gonocoxopodites articulated to the inner faces of the latter distad of the bases of the penis valves. These structures usually project freely and are separate from the penis.

Gonostyli—The styli articulated to the apices of the gonocoxites.

Gonoforceps—The fused gonocoxites and gonostyli, or a generalized collective term for both of these structures when present.

Penis—The intromittent organ proper or phallus. This structure, which is not of appendicular origin, terminates in the gonopore.

Aedeagus—The penis and penis valve. The penis valves are sometimes completely fused with the outer wall of the penis.

Genital foramen—The opening surrounded by the bases of the gonocoxites when the latter are fused both above and below the base of the aedeagus.

Aedeagal foramen—The opening for the ejaculatory duct at the base of the aedeagus when the penis valves are fused completely around the base of the penis.

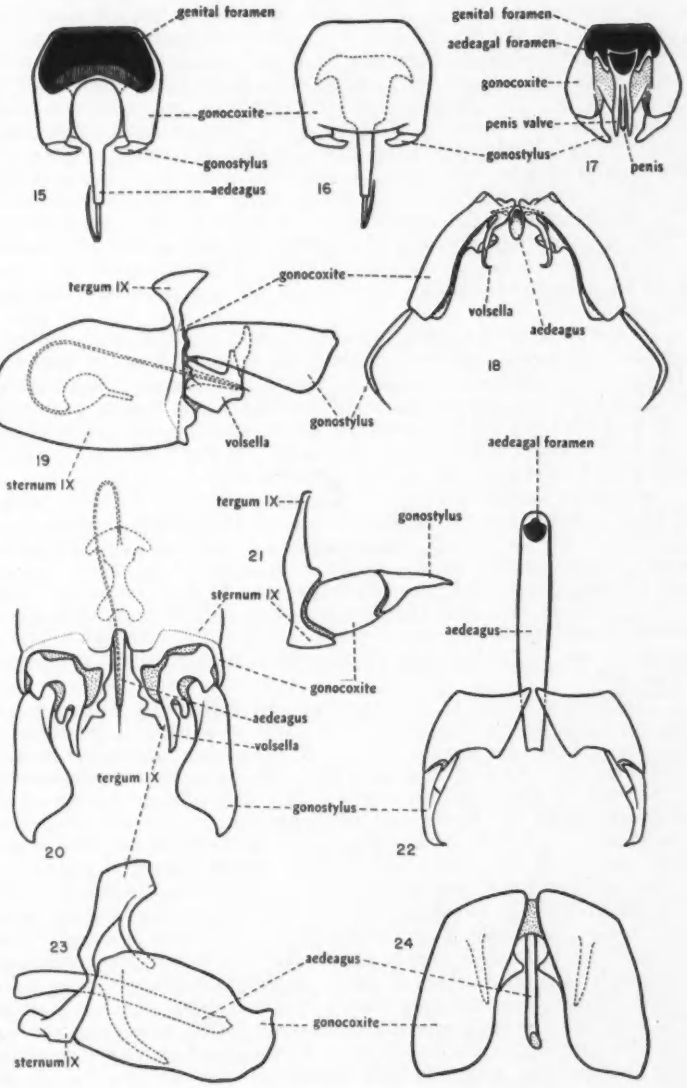
Making use of this terminology, the homologies between male and female parts indicated above are shown in the following tables and in figures 1 and 2.

	FEMALE	MALE
Coxites of eighth abdominal segment	First valvifers	Absent in Pterygota
Gonapophyses of eighth abdominal segment	First valvulae	Absent in Pterygota
Coxites of ninth abdominal segment	Second valvifers	Gonocoxites
Gonopophyses of ninth abdominal segment	Second valvulae	Penis valves (?)
Styli of ninth abdominal segment	Third valvulae or gonostyli	Gonostyli

Comparative anatomy: The appendages of the eighth and ninth abdominal segments of the male *Machilis* (fig. 7) are very similar, except for a shortening of the parts, to the comparable appendages of the female (fig. 3). There can be no doubt that the styli, coxites, and gonapophyses of the male are homologous to those of the female. The only external genital structure of the male without an obvious counterpart in the female is the penis.

EXPLANATION OF PLATE II

15 and 16. Dorsal and ventral views of male primary copulatory organs of *Apterobittacus apterus* (M'Lachlan) [Mecoptera]. 17. Dorsal view of male primary copulatory organs of a stratiomyiid [Diptera]. 18. Morphologically ventral view of male primary copulatory apparatus and associated structures of *Aedes dorsalis* [Diptera]. 19 and 20. Lateral and ventral views of male primary copulatory organs and associated structures of *Ctenophora* sp? [Diptera]. 21 and 22. Lateral and ventral views of male primary copulatory organs and associated structures of *Dicosmoecus atripes* Hagen [Trichoptera]. 23 and 24. Lateral and ventral views of male primary copulatory organs and associated structures of *Prionoxystus robiniae* (Peck) [Lepidoptera].


genital foramen
gonocoxite
gonostylus
aedeagus
15
16
genital foramen
aedeagal foramen
gonocoxite
penis valve
gonostylus
17
penis
tergum IX
gonocoxite
volsella
gonostylus
19
sternum IX
volsella
aedeagus
18
tergum IX
gonostylus
21
sternum IX
gonocoxite
aedeagus
volsella
tergum IX
gonostylus
20
aedeagal foramen
aedeagus
22
23
aedeagus
gonocoxite
sternum IX
24

Turning to the Pterygota, we find ordinarily no appendages on the eighth abdominal segment of adult males. The appendages of the ninth segment are similar to those of *Machilis* in certain Neuroptera (e.g., *Agulla* in the Raphidiidae). In these structures the supposedly primitive orthopteroid orders are far more modified than some of the Neuroptera and certain other orders with a complete metamorphosis. In *Agulla* (fig. 8) the gonocoxites, gonostyli, and penis are clearly homologous with those of *Machilis*. The base of each gonocoxite is produced as a thickening in the ventral wall of the penis. While these thickenings may be homologous to the gonapophyses of *Machilis*, their entirely different relation to the penis leaves the homology in doubt. The thickenings are the penis valves. Laterad of the penis valves lies a pair of projecting processes which were called fragmenta of the coxopodites by Ferris and Pennebaker (1939). These processes are apparently homologous with the claspettes of Diptera and the volsellae of Hymenoptera.

In the mantispid *Climaciella* (figs. 9 and 10) the penis valves, if present, are fused together (as they are apically in some species of *Agulla*) and separated from the gonocoxites, the gonostyli are absent or fused with the gonocoxites, and the volsellae are absent. A sclerotic arch extends between the bases of the gonocoxites over the aedeagus. This arch appears to be a fusion product of the bases of the gonocoxites analogous to the gonobase of the Hymenoptera.

In several groups of Neuroptera claspers are found which, because of their articulation to the ninth abdominal segment, appear to be gonopods. In the sialids, for example, a pair of large clasperlike structures articulates on the posterior margin of the ninth tergum, and in some genera, such as *Neohermes*, the true gonocoxopodites are absent. These secondary claspers are paraprocts or parts of the completely divided tenth tergum; they are clearly visible although relatively small in size on either side of the anus in mantispids (*Plega* and *Climaciella*).

The male genitalia of Hymenoptera are sufficiently similar to one another than within the order their parts may usually be definitely homologized (see Snodgrass, 1941). A comparison of the genitalia of *Xiphydria* (fig. 11) with those of *Agulla* (fig. 8) shows the relationships of the parts between the two orders. The chief differences between the gonocoxopodites of *Agulla* and of *Xiphydria* are the formation of a gonobase in the latter, the formation of an apodeme at the base of each penis valve and the separation of these valves from the gonocoxites in the hymenopteron, and the position of the entire genital armature of *Xiphydria* in the membrane above (morphologically behind) rather than immediately behind and articulated to the ninth sternum. That the gonobase is actually merely a secondary division of the gonocoxites is shown by the observation of Zander (1900) who found that in *Vespa* it is separated from the gonocoxites late in ontogenetic development. This conclusion is supported by Crampton (1938), who notes particularly the notching of the gonobase in *Xyela*. Certain special modifications within the order include fusion of the gonocoxites in the Chrysididae, separation of the penis valve from the penis in most

bees, and nearly complete suppression of all parts of the primary copulatory organs except for the large and complex penis in *Apis*.

In the Coleoptera, as in the Hymenoptera, the genitalia are free from, rather than firmly articulated to the ninth abdominal sternum. Hence, they have frequently been regarded as entirely of phallic origin or as consisting of the penis and penis valves alone (Metcalfe, 1932). However, the musculated lateral processes have the characteristics of gonostyli (whose bases are sometimes fused as in *Hydrous*, fig. 12) and are articulated to the usually fused gonocoxites. The penis valves bear basal apodemes as in the Hymenoptera and are distally fused to one another in *Hydrous* (figs. 12 and 13). As shown by Sharp and Muir (1912), the gonostyli are absent in many forms, but in such cases the fused gonocoxites cover the base of the aedeagus. In *Hydrous*, as in many other insects, the gonocoxites are fused only beneath the aedeagus, but in many Coleoptera they are fused both above and beneath.

The gonocoxites of the Mecoptera (*Apterobittacus apterus* (M'Lachlan), *Bittacus chlorostigma* (M'Lachlan), and *Panorpa nuptialis* Gerstaecker) are fused both above and below the base of the aedeagus, encircling a genital foramen. The gonocoxites, which are articulated to the ninth sternum, are thus immovably fixed together. The gonostyli are conspicuous and attached to the free apices of the gonocoxites. Volsellae are absent. In *Apterobittacus* and *Bittacus* the base of the penis is enlarged and highly sclerotic, somewhat invaginated. This sclerotization may represent the fused penis valves. In *Panorpa*, as shown by Ferris and Rees (1939), structures called hypomeres by these authors, but which may be penis valves, are present on the otherwise largely membranous penis. The tergum of the ninth segment in *Apterobittacus* and *Bittacus* is produced as a pair of clasperlike projections.

In Diptera there is great variation in the male genitalia as shown by the numerous figures of Cole (1927). The styli and gonocoxites are usually present, articulated to the posterior margin of the ninth sternum. They are fused to form a bridge beneath the aedeagus in the Stratiomyiidae (e.g., *Geosargus viridis* (Say)), greatly shortened and partly fused to the ninth sternum and tergum in Tipulidae. The volsellae are present in *Chironomus* (Chironomidae), *Aedes* (Culicidae) (fig. 18) and in *Ctenophora* (figs. 19 and 20), *Tipula*, *Holorusia*, etc. (Tipulidae). However, in the stratiomyiids studied they are absent. In this group the penis valves are conspicuous, retaining their attachment to the gonocoxites and being fused basally around the penis to enclose an aedeagal foramen. In the tipulids examined the penis valves, if present, are greatly modified, free from the gonocoxites, and provide the sclerotization of the invaginated base of the penis. In *Chironomus*, *Aedes* and *Anopheles* penis valves are absent, the penis being short and membranous. The small sclerites at the bases of the outer sides of the gonocoxites of mosquitoes appear to me to be mere fragmenta of these gonocoxites. To regard them as the vestiges of the gonocoxites requires that the styli be two-segmented, or three-segmented, counting the apical clawlike structure, a condition not

clearly demonstrable in any forms examined except certain ephemerida in which the segmentation lacks musculation and is perhaps secondary.

The gonostyli in the Trichoptera are frequently absent or possibly fused with the gonocoxites. In some forms, however, the gonostyli are very small and in a few (*Dicosmoecus*, figs. 21 and 22, and *Neuronia*) the styli are large. The gonocoxites are articulated to the posterior margin of the ninth sternum and are sometimes fused to form a bridge beneath the aedeagus. The latter is invaginated and the exposed surface is sclerotic, possibly indicating the presence of fused penis valves separated from the gonocoxites.

The homologies of the parts of the male genitalia of the Lepidoptera remain in considerable doubt. In this order the claspers or valves (or harpes) are one-segmented. In view of the reduction of the gonostyli seen in the Trichoptera, it seems reasonable to regard them as absent in the Lepidoptera, the remaining structures, of course, being gonocoxites. The articulated and musculated process arising on the inner surface of each gonocoxite, termed clasper by many lepidopterists and homologized with the stylus by Forbes (1939), is probably the volsella. If this is the case, the penis valves are probably fused to form the juxta. The gonocoxites are fused basally beneath the aedeagus or penis in some forms. In *Prionoxystus robiniae* (Peck) (figs. 23 and 24), *Bombyx mori* Linnaeus, and *Tineola biselliella* Hummel the gonocoxites are articulated to the posterior margin of the ninth sternum. In *Carpocapsa pomonella* (Linnaeus) they are also articulated to a plate which may represent the fused bases of the penis valves.

The gonoforceps of Hemiptera, as in the Lepidoptera, are one-segmented. There is no evidence to indicate whether they represent the gonocoxites alone or the gonocoxites fused with the gonostyli. Hence the term gonoforceps is used. They are articulated to the posterior margin of the ninth sternum, which in many Heteroptera is large and deeply cupped with its posterior margins invaginated into the hollow; the gonoforceps arise from deep within this cavity. The gonoforceps and aedeagus are directed posteriorly in *Belostoma*, upward but with bases largely visible in *Saldula interstitialis* (Say) (fig. 25) and *Notonecta*, and largely hidden within the hollow of the ninth sternum in *Anasa tristis* (De Geer), *Leptoglossus occidentalis* Heidemann, etc. In the Heteroptera the penis sometimes contains a pair of sclerotic rods

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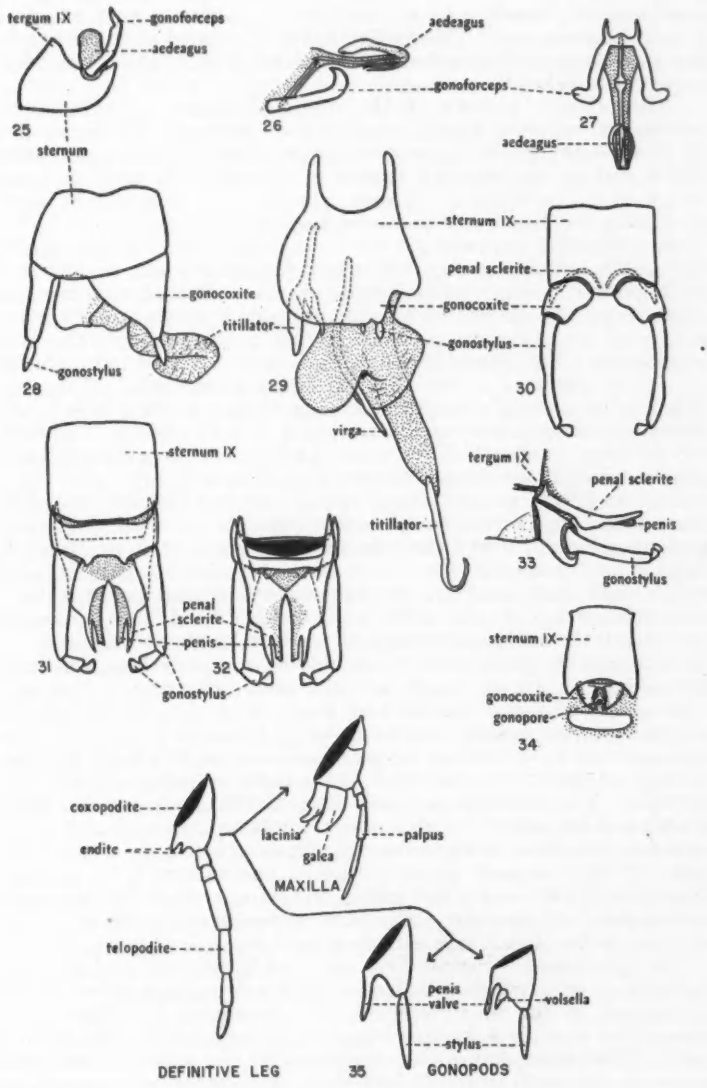
EXPLANATION OF PLATE III

25. Lateral view of male primary copulatory organs and associated structures of *Saldula interstitialis* (Say) [Hemiptera]. 26 and 27. Lateral and ventral views of male primary copulatory organs of *Cixus* sp? [Homoptera]. 28. Ventral view of male primary copulatory organs and associated structures of *Grylloblatta campodeiformis* Walker [Orthoptera] (after Walker). 29. Ventral view of male primary copulatory organs and associated structures of *Blattella germanica* (Linnaeus] [Orthoptera]. 30. Ventral view of male primary copulatory organs and associated structures of *Callibaetis* sp? [Ephemerida]. 31, 32, 33. Ventral, dorsal, and lateral views of male primary copulatory organs and associated structures of *Paraleptophlebia pallipes* (Hagen) [Ephemerida]. 34. Ventral view of male primary copulatory organs and associated structures of *Lestes* sp? [Odonata]. 35. Diagram suggesting the parallel reduction which has evidently occurred from walking leg to maxilla and to male gonopod.


tergum IX
gonoforceps
aedeagus
25
sternum
aedeagus
gonoforceps
26
aedeagus
27
gonocoxite
titillator
gonostylus
28
sternum IX
penal sclerite
gonocoxite
gonostylus
29
virga
titillator
30
sternum IX
penal sclerite
31
penis
gonostylus
32
tergum IX
penal sclerite
penis
33
gonostylus
sternum IX
gonocoxite
gonopore
34
coxopodite
endite
telopodite
lacinia
galea
palpus
MAXILLA
DEFINITIVE LEG
penis valve
stylus
volsella
35
GONOPODS

which may be remnants of penis valves. In the Homoptera (Singh-Pruthi, 1924) the penis valves may be separate from one another but are commonly fused to form a median, sometimes jointed, rod as in *Cixus*, *Idiocerus*, etc. This median rod is articulated at its base to the separate bases of the gonoforceps (gonocoxites) or to the bridge which unites them below the aedeagus.

The primary genitalia in the supposedly primitive orthopteroid orders are far more highly modified than those of the Neuroptera. In *Grylloblatta* (fig. 28) the gonocoxites are separated from one another, articulated on the posterior margin of the ninth sternum, and each furnished with a stylus at its apex. In the other orthopteroid insects (including the Isoptera) the gonocoxites are fused to each other and to the ninth sternum, forming a coxosternum (as shown by Walker, 1922; Else, 1934; and Snodgrass, 1937) which frequently bears the gonostyli on its posterior margin, as in *Blattella* (fig. 31). In the Locustoidea and Phasmoidea the coxosternum is divided by a transverse suture or impressed line; the area posterior to this line is probably the fused gonocoxites. The homologies of the other parts of the primary copulatory organs of the orthopteroid orders are doubtful. The penis, although apparently virtually absent as distinct projection in *Grylloblatta*, is usually distinct and is supported in some cases by a sclerotic rod or virga. Laterad of the penis lies a pair of lobes the sclerotic portions of which are termed titillators by Walker (1922). Else (1934) and Qadri (1940), on the basis of ontogenetic development, state that these lobes are derivatives of appendages of the tenth abdominal segment. Even if they arose from the ninth segment, it would not be possible to homologize them with certainty with volsellae or penis valves since their bases are membranous and do not clearly indicate their relationship, if any, to the gonocoxites. Until their homologies are settled, these lobes of Orthoptera are best known as titillators.

Although the gonocoxites of mayflies have usually been illustrated as fused in papers on insect genitalia, there are many groups (e.g., *Ephemera*, *Callibaetis*, fig. 30, and *Baetis*) in which the gonocoxites are free from one another. In the majority of ephemerids (e.g., *Paraleptophlebia*, figs. 31, 32 and 33) the gonocoxites are broadly fused together, forming a broad plate articulated to the posterior margin of the ninth sternum. The gonostyli are articulated to the apices of the gonocoxites and are usually divided into a number of segments. It seems probable that these divisions are only secondary because of the variability in their number and the lack of musculature between them (Snodgrass, 1936). As is well known, in this order there are two penes, each opening in a gonopore. The outer surface of each penis is sclerotic and the sclerite of each side articulates with the outer upper basal angle of the gonocoxite. Hence these penal sclerites are probably not homologous with either volsellae or penis valves, both of which are articulated on the inner sides of the gonocoxites. Walker (1922) states that there is a paramere laterad of each penis valve, but as Qadri (1940) has pointed out, parameres in the sense of true penis valves do not occur in the Ephemerida. It seems worth emphasizing that the existence of the two penes in the Ephemerida and Dermaptera may be a derived rather than a primitive character, especially in view

of the presence of two separate penes in certain Cerambycidae (Coleoptera) as shown by Sharp and Muir (1912).

Probably as a result of the existence of secondary copulatory structures, the primary copulatory organs are greatly reduced in Odonata. However, a pair of small plates whose homologues are said to bear styli in the nymphs are evidently remnants of gonocoxites and lie on either side of the penis (fig. 34).

In the Plecoptera, Embioptera, and apparently in the Dermaptera, as well as in certain representatives of many of the other orders the gonopods of the males are lost, claspers if present being derived from other structures.

In summarizing these observations on gonopods the following points may be noted:

1. The homologies already suggested (by our knowledge of ontogeny and sex anomalies) between the parts of the gonopods of male and female insects are verified by the comparative morphological evidence.
2. The outer claspers (gonoforceps) are homologous throughout most of the orders of insects. The homologies of the inner pairs of claspers are as yet less certain.
3. The gonostyli are one-segmented except in the Ephemerida. While the gonopore is the best landmark in the genital region, the gonostyli are reasonably constant.
4. It is often difficult to determine whether a one-segmented outer clasper represents a gonocoxite alone (gonostylus lost), a fusion product of gonocoxite and gonostylus, or a gonostylus alone (gonocoxite indistinguishably fused with ninth abdominal sternum). It has not always been possible to solve such problems in cases where no related forms with two-segmented outer claspers (gonoforceps) exist. However, the following points must be kept in mind in determining the nature of one-segmented outer claspers: Volsellae are articulated to the gonocoxites; penis valves primitively are attached to the gonocoxites and frequently retain this relationship; neither they nor the penis itself are attached directly or through membranes to the gonostyli.
5. The basal fusion of the gonocoxites has occurred independently in many different orders of insects.

It is interesting to compare the reduction of the various gnathocephalic appendages with that of the gonopods. While it could not necessarily have been predicted that evolution of these widely separated appendages of the same series would be parallel, it appears to have been so, as illustrated by the accompanying diagrams (fig. 35). The telopodite of the hypothetical primitive walking leg is shown to have been reduced to the palpus in the maxilla and probably to the stylus in the gonopod, while the endites of the coxopodite are enlarged in both the maxilla and the gonopod. It is not possible to regard the inner and outer processes of the gonopods as endopodites and exopodites of biramous appendages since the exopodite of such an appendage arises from the trochanter and is part of the telopodite. The absence of evidence of biramous appendages elsewhere in insects is a further indication that the bilobed condition commonly found in the male gonopods is in no way related to the biramous condition of many crustacean appendages.

LITERATURE CITED

Bischoff, H. and **W. Ulrich.** 1929. Über einen Gynander der Mauerbiene (*Chalcidoma muraria* Retz.). Zeits. f. Morph. u. Ökol. der Tiere, 15: 213–261, 22 figs.

Cappe de Baillon, P. 1924. Recherches sur le gynandromorphisme *Metrioptera brachyptera* L. et *Leptophyes punctatissima* Bosc (Orthoptera; Phasgonurides), La Cellule, 34: 71–129, 8 figs., 3 pls.

1932. Gynandromorphes de *Leptophyes punctatissima* Bosc (Orth., Phasgonuridae). Bull. Soc. ent. France, 37: 177–180, 3 figs.

Cole, Frank R. 1927. A study of the terminal abdominal structures of male Diptera (Two-winged flies). Proc. Calif. Acad. Sci., (4)16: 397–499, 22 pls.

Crampton, G. C. 1919. The genitalia and terminal abdominal structures of males, and the terminal abdominal structures of the larvae of "Chalastogastrous" Hymenoptera. Proc. Ent. Soc. Wash., 21: 129–148.

1920. Remarks on the basic plan of the terminal abdominal structures of the males of winged insects. Can. Ent., 52: 178–183, 9 figs.

1920a. A comparison of the genitalia of male Hymenoptera, Mecoptera, Neuroptera, Diptera, Trichoptera, Lepidoptera, Homoptera and Strepsiptera, with those of lower insects. Psyche, 27: 34–45, 21 figs.

1921. Correction of a statement concerning the terminal abdominal structures of male insects. Can. Ent., 53: 72.

1938. The structures called parameres in male insects. Bull. Brooklyn Ent. Soc., 33: 16–24, 9 figs.

Else, F. L. 1934. The developmental anatomy of male genitalia in Melanoplus differentialis (Locustidae, Acrididae, Orthoptera). Jour. Morph., 55: 577–609, 4 pls.

Ferris, G. F. 1940. The morphology of Plega signata Hagen (Neuroptera: Mantispidae). Microent., 5: 33–56, 15 pls.

Ferris, G. F. and **Phyllis Pennebaker.** 1939. The morphology of Agulla adnixa (Hagen) (Neuroptera: Raphidiidae). Microent., 4: 121–142, 13 pls.

Ferris, G. F. and **Bryant E. Rees.** 1939. The morphology of Panorpa nuptialis Gerstaecker (Mecoptera: Panorpidae). Microent., 4: 79–108, 16 pls.

Forbes, Wm. T. M. The muscles of the lepidopterous male genitalia. Ann. Ent. Soc. Amer., 32: 1–10, 5 figs.

Freeborn, Stanley B. 1924. The terminal abdominal structures of male mosquitoes. Amer. Jour. Hygiene, 4: 188–202, 18 figs.

Johannsen, Oskar A. and **Ferdinand H. Butt.** 1941. Embryology of insects and myriapods. McGraw-Hill Book Co., New York City, xi+462 pp., 370 figs.

Mehta, Dev Raj. 19.33 On the development of the male genitalia and the efferent genital ducts in Lepidoptera. Quart. Jour. Micr. Sci., (n.s.) 76: 35–61, 18 figs.

Metcalfe, Margot E. 1932. The structure and development of the reproductive system in the Coleoptera with notes on its homologies. Quart. Jour. Micr. Sci., (n.s.) 75: 49–129, 49 figs., 4 pls.

Newell, Anna Grace. 1918. Comparative morphology of genitalia of insects. Ann. Ent. Soc. Amer., 11: 109–142, 14 pls.

Ohmachi, Fumiye. 1926. Preliminary note on a gynandromorph of Madasumma marmorata. Proc. Imp. Acad., Tokyo, 2: 554–558, 3 figs.

Peacock, A. D. 1924. On the males and an intersex-like specimen of the parthenogenetic saw-fly, Pristiphora pallipes, Lep. Brit. Jour. Expt. Biol., 1: 391–412, 2 pls.

1925. Studies in the parthenogenensis and sexuality of saw-flies (Tenthredinidae). Brit. Jour. Expt. Biol., 3: 61–84, 2 pls.

Peck, Oswald. 1937. The male genitalia in the Hymenoptera (Insecta) especially the family Ichneumonidae. Canad. Jour. Research, (D)15: 221–274, 158 figs.

Popov, V. B. 1935. Ein Fall von teratologischem Hermaphroditismus bei Andrena agilissima Scop., Rev. Ent. U. R. S. S., 26: 160–164, 2 figs. (in Russian).

1937. Gynandromorphism and the effect of parasitic castration (Stylopization). Bull. Acad. Sci. U. S. S. R., pp. 485–494, 3 figs. (in Russian).

Qadri, M. A. H. 1940. On the development of the genitalia and their ducts of orthopteroid insects. Trans. Royal Ent. Soc. London, 90: 121–175, 17 figs., 7 pls.

Snodgrass, R. E. 1935. Principles of insect morphology. McGraw-Hill Book Co., New York City, ix+667 pp., 319 figs.
1936. Morphology of the insect abdomen, part III, the male genitalia. Smithsonian Misc. Colls., 94(14): 1–96, 29 figs.
1937. The male genitalia of orthopteroid insects. Smithsonian Misc. Colls., 96(5): 1–107, 42 figs.
1941. The male genitalia of Hymenoptera. Smithsonian Misc. Colls., 99(14): 1–85, 6 figs., 33 pls.
Sharp, D., and **F. Muir.** 1912. The comparative anatomy of the male genital tube in Coleoptera. Trans. Ent. Soc. London, 1912: 477–641, 36 pls.
Singh-Pruthi, Hem. 1924. The development of the male genitalia of Homoptera, with preliminary remarks on the nature of these organs in other insects. Quart. Jour. Micr. Sci., (n.s.) 69: 59–96, 2 pls.
1925. The morphology of the male genitalia in Rhynchota. Trans. Ent. Soc. London, 1925: 127–267, 27 pls.
1929. Homologies of the genitalia of insects. Ent. Monthly Mag., 65: 189–201.
Walker, E. M. 1919. The terminal abdominal structures of orthopteroid insects: a phylogenetic study. Ann. Ent. Soc. Amer., 12: 267–326, 9 pls.
1922. The terminal structures of orthopteroid insects: a phylogenetic study, Part II. Ann. Ent. Soc. Amer., 15: 1–76, 7 figs., 11 pls.
Zander, E. 1900. Beiträge zur Morphologie der männlichen Geschlechtsanhänge der Hymenopteren. Zeitschr. wiss. Zool., 67: 461–489, 1 pl.
1901. Beiträge zur Morphologie der männlichen Geschlechtsanhänge der Trichopteren. Zeitschr. wiss. Zool., 70: 192–235, 1 pl.
1903. Beiträge zur Morphologie der männlichen Geschlechtsanhänge der Lepidopteren. Zeitschr. wiss. Zool., 74: 557–615, 15 figs., 1 pl.

MOSQUITO CONTROL. Practical Methods for the Abatement of Disease Vectors and Pests, by WM. B. HERMS AND H. F. GRAY. xiv+419 pages, 9 tables, 11 plates, 86 figures, 1 folded chart. The Commonwealth Fund, 41 East 57th Street, New York 22, N. Y. 1944. Price $3.50.

The first edition was reviewed in the Ann. Ent. Soc. Amer., 35: 109, 1942. It was reprinted four times and now appears in a splendid second edition. The conspicuous differences to be noted in a cursory examination are: larger size, better and more numerous illustrations, and new additions consisting of a large folded chart with information on the ecology and control of the principal malarial mosquitoes, a section on mosquito vectors of diseases other than malaria, and a section on identification of mosquitoes and hints on the use of keys. With the inclusion of this new material the book becomes even of greater value and especially to those users of it who have limited library facilities.

More detailed examination reveals inclusion of much new information on methods of control in parts of the world other than the United States and this greatly enhances the military value of the book. For instance, much use is made of the extensive findings of Sir Malcolm Watson. The material on larvicides and sprays, aerosols, and repellents against adults is brought up to date and includes important knowledge on phenothiazine, DDT, dimethyl phthalate, and Rutger's 612. Many citations to published literature have been added and recent publications are included.

As stated above, the second edition is larger in size because it has 102 additional pages. However, probably due to government regulations for the conservation of paper, the margins are smaller so that the height and width of the new edition are less than the first. The quality of the paper is good and the physical appearance of the book meets the high standards characteristic of the publications of the Commonwealth Fund.—C. E. VENARD.

NEW NORTH AMERICAN TACHINIDAE BELONGING TO THE GENUS MUSCOPTERYX[1]

(Diptera)

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Muscopteryx Townsend was originally proposed in 1892 for the reception of a single species, *chaetosula*, from Mexico (Can. Ent., XXIV: 170). No additional forms were subsequently ascribed to the genus, however, the genotype received two superfluous baptisms during the intervening years. In 1897, Coquillett in his well known Revision of North American Tachinidae, described it as *Brachicoma pulverea*, new species, from a single female specimen collected at San Diego, Texas, and Townsend, 1915, proposed *Psammoppia*, new, with *pulverea* as the type, without any description of generic characters (Proc. Biol. Soc. Wash., XXVIII: 20). This synonymy was published by Townsend (Manual of Myiology, Part IX, 1939) with a redescription of the genus. The latter is readily accessible and detailed generic characters need not be repeated here.

I am indebted to Dr. R. H. Beamer for the privilege of studying the type specimen (a female labeled "Chihuahua, Mexico, Aug. 4, Townsend") in the Kansas University Collection. The peculiar or distinguishing characters may be briefly listed as follows:

MUSCOPTERYX: GENOTYPE CHARACTERS

Eyes sparsely hairy; parafacial one-half clypeal width, with an oblique row of six infraclinate bristles (smaller than average frontal) which appear as a continuation of frontal row; lowermost frontal beneath antennal base and not strongly divergent from main row; antennae reaching below middle of face, segments two and three subequal in length; arista short, practically bare; thickened at extreme base; ocellars proclinate; outer verticals vestigial; facial ridges bare; vibrissal axis well above lower edge of head and three-fourths antennal; cheek one-fourth eye height; proboscis short, moderately stout; palpi slender; back of head evenly moderately bulged. Thoracic chaetotaxy: acrostichal 2, 3 (none immediately before suture); dorsocentral 3, 3; intraalar 3; supraalar 3; postalar 2; notopleural 2; presutural 1 (outer); humeral 4–5; posthumeral 1; pteropleural 1 (small); sternopleural 2; scutellum with 2 long lateral, 1 strong decussate apical and 1 slender discal pair; propleura haired; prosternum (damaged in type specimen); infrasquamal hairs present. Abdomen with a pair of discals on segment 2 and 3; sternites covered. Hind tibiae not ciliate; claws and pulvilli short. Wings extending

[1]Contribution No. 778, Division of Entomology, Texas Agricultural Experiment Station.

slightly beyond tip of abdomen; first vein bare, third with 4 setulae near base; first posterior cell nearly closed at costa well before wing tip; last section of fifth vein short; costal spine longer than small cross vein; epaulets blackish. Length, 6.5 mm.

The new species here described agree closely with most of the items mentioned above. The principal distinguishing characters given under the descriptions are listed for ready reference in the following key. Unless otherwise indicated, types of the new species are in my collection.

KEY TO SPECIES OF MUSCOPTERYX

1. Abdomen largely gray pollinose and usually densely so 3
   Abdomen shining black with silvery pollen bands on basal margin of one or both intermediate segments 2
2. Front before ocelli exceeding one-half eye width in both sexes; male with two pairs of strong proclinate orbitals; wings blackish basally on costal margin. California. (p. 357) ..... **nitida**
   Front before ocelli narrowed to one-fourth eye width and lacking orbital bristles in male; wings subhyaline; female unknown. Texas. (p. 356). **parilis**
3. Palpi yellow to brownish 4
   Palpi black; parafacial bristles longer than frontals; antennae wholly black; abdomen strongly bristled; male only. California. (p. 355) ..... **longiseta**
4. Thorax not distinctly vittate behind suture; proximal antennal segments reddish yellow 6
   Thorax with two broad uninterrupted dark vittae extending behind suture almost to scutellum; proximal antennal segments infuscated; cheek nearly two-fifths eye height 5
5. Parafacial gray pollinose, about three-fourths clypeal width; propleura very distinctly haired; male only. Texas. (p. 355) ..... **hilaris**
   Parafacial with satiny light brownish pollen, equal clypeal width; propleura with only two or three short inconspicuous hairs; male only. Wisconsin. (p. 355) ..... **hiemalis**
6. Cheek one-fourth eye height; propleura haired; parafacial one-half clypeal width; infrasquamal hairs present. Texas, Mexico. (p. 353) ..... **chaetosula**
   Cheek nearly one-half eye-height; propleura bare; parafacial subequal clypeal width, infrasquamal hairs absent. Florida. (p. 354) ..... **hinei**

Muscopteryx chaetosula Townsend

The principal references to the species have been cited above. Also, most of the essential specific characters have been listed to which may be added the following:

Body rather densely gray pollinose; male front at vertex 0.16 to 0.18 and in female 0.30 of head width; palpi yellow; orbitals lacking in male, the pulvilli elongate and discals on intermediate abdominal segments usually doubled; genitalia blackish; inner forceps united, keeled behind and tapering to a blunt tip which is slightly and subacutely produced on the anterior extremity, outer forceps brownish, rather slender and a trifle shorter; fifth sternite black, with a narrow deep median incision, lobes sparsely black-haired; female genitalia not adapted for piercing.

Four males and one female collected in Bexar, Duval and Hidalgo Counties, Texas, April 9 to May 14 (E. A. Schwarz; H. B. Parks; S. W. Clark). There is apparently no information available concerning the biology or host relationships.

Muscopteryx hinei, n. sp.

Male.—Front at vertex 0.25 of head width (average of three specimens), narrowed before ocellar triangle thence widening rapidly to antennal base; parafrontals, parafacials and cheeks densely gray pollinose; median stripe reddish, wider than parafrontal except on anterior extremity; parafacial bristles about as strong as average frontal; clypeus only slightly sunk and hardly equal parafacial width; cheek clothed with coarse or bristly hairs, nearly one-half eye height; antennae reaching well below middle of face, first segment slightly elongate, second reddish and about four-fifths length of third; arista black, bare, with short basal segments; palpi moderately slender, yellow; eyes thinly hairy, reaching almost to level of vibrissae; back of head convex and thickly gray pollinose, moderately clothed with pale hairs intermixed with black ones on upper extremity.

Thorax black, densely gray pollinose, notum not distinctly vittate; chaetotaxy as in *chaetosula;* prosternum, propleura, and sides of postnotum beneath calypters bare; infrascutellum normally developed; calypters subopaque, white.

Abdomen slightly elongate, narrower than thorax, black and wholly gray pollinose; first two segments with pair of median marginal bristles, last two with marginal row; one discal pair on intermediate segments and discal row on anal segment; genitalia about as in *chaetosula.*

Legs moderately long, black with an obscure reddish tinge in ground color of tibiae; claws and pulvilli subequal length of apical tarsal segment.

Wings subhyaline; fourth vein with a rounded stumpless bend, thence slightly bowed inward closing first posterior cell at or near costa well before extreme wing tip; hind cross vein bicurved, joining fourth about two-fifths distance from bend to small cross vein; third vein with 5 or 6 setulae extending almost halfway to small cross vein; costal spine distinctly longer than small cross vein; epaulets infuscated.

Female.—Front at vertex 0.31 of head width (one specimen), widening gradually from near middle to antennal base; two strong proclinate orbitals present; palpi moderately stout and a trifle thickened apically; claws and pulvilli short; otherwise as in male.

Length, 7–8.5 mm.

Holotype male, allotype female, and two paratype males, all labeled "S. Fla., March, 1923;" collected by the late James S. Hine, for whom the species is named. The type and one paratype are returned to J. N. Knull, Ohio State University Museum, to whom I am indebted for the privilege of studying this and other material.

The bare propleura may eventually be considered of sufficient importance to preclude the species from the present genus. However, for what it is worth, it may be pointed out that the propleural vestiture in *chaetosula* is subject to considerable variation. One male example in my collection shows only two or three minute hairs on the propleura as compared with a distinctly haired condition in the female type specimen.

Muscopteryx hilaris, n. sp.

Very similar to the preceding species but the thorax distinctly vittate and the propleura haired. Other differences may be noted as follows:

Male.—Front at vertex 0.20 of head width; median stripe black, nearly equibroad and wider than parafrontal, latter gray pollinose; antennae blackish, first segment short, second and third subequal in length; parafacial about three-fourths clypeal width, bristles in a slightly oblique row and a trifle shorter than frontals; cheek almost two-fifths eye height, moderately clothed with fine black hairs; palpi slender to tips, yellow; eyes moderately haired, in profile reaching to level of vibrissae. Thorax and scutellum black, with rather thick grayish pollen; notum marked with two broad dark sublateral stripes and a less defined median one which extend behind suture almost to scutellum; chaetotaxy as in *chaetosula;* prosternum bare and sides of postnotum beneath calypters nearly so, latter opaque, white. Abdomen black, wholly densely gray pollinose, moderately elongate and but slightly narrower than thorax; genitalia largely reddish yellow, otherwise about as in *chaetosula.* Legs longish, black except tibiae which are obviously reddish, claws and pulvilli as long as last tarsal segment. Wings normal in shape; first posterior cell closed and short petiolate; third vein with 2 to 4 setulae near base; costal spine slightly exceeding length of small cross vein; epaulets reddish. Length, 7 mm. Female unknown.

Holotype: College Station, Texas, March 15, 1937 (H. J. Reinhard). One paratype labeled "Austin, Texas, April 10, 1933," without collector's label.

Muscopteryx hiemalis, n. sp.

Differs from *hilaris* in only minor details and additional material may show it to fall within specific variation of same. To the differences mentioned in the key may be added a few additional items as follows:

Male.—Front considerably more constricted upwards and at vertex 0.14 of head width, median stripe also strongly narrowed above middle; parafrontals with light brownish satiny pollen, very narrow at ocellar triangle and widening rapidly downward; sides of postnotum beneath calypters with cluster of fine hairs; genitalia wholly blackish; claws and pulvilli longer than apical tarsal segment; costal spine about equal length of small cross vein; first posterior cell narrowly open; epaulets blackish. Length, 7 mm. Female not known.

Holotype: Madison, Wisconsin, June 11, 1925, donated by Dr. C. L. Fluke.

Muscopteryx longiseta, n. sp.

Body blackish in general aspect but not shiny; abdomen conspicuously gray pollinose and strongly bristled. The black palpi readily distinguish the species from all others here included.

Male.—Front at vertex 0.15 of head width, hardly widening to middle of front, thence rapidly so downward to antennae; sides

of front and face including cheeks black in ground color, with gray or almost plumbeous pollen; frontal vitta black, strongly narrowed upwards but wider than parafrontal except on anterior extremity; antennae jet-black, third segment a trifle longer than second which bears numerous spiny hairs on front edge; arista short, bare, bulbous near base and very slender beyond; parafacial equibroad, hardly three-fourths clypeal width, bearing a row of seven longish, infraclinate bristles; proboscis short, stout; palpi black, but slightly thickened apically; cheek with long black hairs, nearly one-third eye height; eyes distinctly but not densely haired, in profile reaching to or slightly below aristal level; back of head somewhat swollen and clothed with short pale fine hairs below middle but with coarser black ones along posterior orbits above.

Thorax and scutellum black dusted with gray pollen; chaetotaxy as in *chaetosula*; prosternum and sides of postnotum beneath calypters bare, latter white and semi-transparent.

Abdomen ovate, slightly narrower than thorax, black, first segment subshining, three following largely gray pollinose; proximal segments each with two pairs of median marginals (outer ones weak), besides several irregularly placed discal pairs on second; third segment bearing a discal and a marginal row, latter long but not uncommonly stout; anal segment wholly bristled above except on narrow basal margin; genitalia retracted, blackish; lobes of fifth sternite subshining, sparsely short-haired.

Legs black, moderately stout; hind tibia with five widely spaced unequal-sized bristles on outer posterior side; claws and pulvilli elongate.

Wings gray hyaline with a slight brownish tinge near base; costal spine about equal length of small cross vein; first posterior cell closed with short petiole reaching costa well before wing tip; third vein setulose nearly halfway to small cross vein; hind cross vein meeting fourth about one-third distance from bend to small cross vein; epaulets black. Female not known.

Length, 7.5 mm.

Holotype: Male, labeled, "California, May 19, 1914," no collector's label.

Muscopteryx parilis, n. sp.

Male.—Differs from *chaetosula* principally by the characters listed in the accompanying key. Other minor differences may be noted as follows:

Front at vertex 0.14 of head width; antennae entirely black; parafrontals and parafacials subsilvery; eyes moderately densely hairy; thorax and scutellum subshining black, with rather even thin white pollen on notum; propleura distinctly hairy; sides of postnotum beneath calypters bare; legs subshining, wholly black; costal spine subequal small cross vein; epaulets black. Length, 6.5 mm.

Holotype: Male, Hartley County, Texas, June 14, 1934.

Muscopteryx nitida, n. sp.

Close to *parilis*, but at once distinguished by the characters listed in the key. Other differences are mentioned below.

Male.—Front at vertex 0.24 of head width, equibroad nearly to middle, thence widening moderately downward to base of antennae; frontal vitta velvety black, wider than parafrontal on entire length; parafrontals, parafacials and cheeks with dense gray pollen; frontal bristles moderately strong, decussate; orbitals two proclinate pairs, stout; inner verticals long and slightly divaricate; ocellars smallish but distinct; parafacial slightly narrowed downward with a row of 7 or 8 bristles nearly as long as average frontal; facial depression rather shallow, its lateral ridges bare; epistoma hardly narrower than clypeus and slightly bowed forward from plane of same; vibrissae doubled, main pair stout, decussate, on oral margin well above lower edge of head; antennae wholly black, reaching lower third of face, second segment equal or slightly exceeding length of third; arista black, short, moderately thickened near base; proboscis short, stout, palpi slender to tips, brownish yellow; cheek with sparse coarse hairs at middle, about one-fourth eye height; eyes distinctly but not thickly hairy, back of head evenly convex, gray pollinose, rather sparsely clothed with fine pale hairs below and coarser black ones above.

Thorax and scutellum black, dusted with moderately heavy grayish white pollen; chaetotaxy as in *chaetosula*, but the intermediate post acrostichal is lacking in type specimen; sides of post notum beneath calypters with a few inconspicuous hairs; propleura sparsely to moderately haired; prosternum bare; calypters opaque white, with hind lobes blackish along inner margin.

Abdomen elongate ovate, narrower than thorax, shiny black with silvery pollen on basal margin of intermediate segments; chaetotaxy as in *longiseta*, but the bristles not quite so strong; genitalia black; inner forceps rather broad and short, weakly keeled behind, tapering to near tip, thence divided and slightly divergent with each prong bowed forward on extreme tip; outer forceps a trifle shorter, but much narrower than inner pair in profile view; fifth sternite narrowly and deeply divided, lobes shining black, beset with scattered fine short black hairs.

Legs rather stout, wholly black; hind tibia with a row of five widely spaced uneven bristles on outer posterior side; claws and pulvilli hardly equal length of last tarsal segment.

Wings subhyaline with a brownish tinge along costa becoming darker or blackish towards base; fourth vein with an almost rectangular bend, latter usually without a stump; first posterior cell closed at costa well before wing tip; hind cross vein oblique to fourth which it joins one-third distance from bend to small cross vein; third vein with about five coarse hairs extending almost halfway to small cross vein; costal spine strong; epaulets black.

Female.—Front at vertex 0.25 of head width (average of two), widening to 0.40 of same at antennal base; arista yellowish beyond basal enlargement; eyes sparsely haired; abdomen with narrower

pollen bands on segments two and three, sometimes almost wanting on latter; median marginals on first two and discals on intermediate segments in single pairs; genitalia terminating in a blunt-tipped organ, not adapted for piercing; claws and pulvilli short; tarsi somewhat thickened and rather stout.

Length, male, 8 mm.; female, 5.5 to 6.5 mm.

Holotype: Male, Pinon Flat, Santa Rosa Mts., California, May 27, 1941, D. J. and J. N. Knull. Paratypes one female, same data as type and one female, Kern County, California, July 19, 1930. The holotype is returned to J. N. Knull for deposit in the Ohio State University Museum Collection.

PARASITIC DISEASES AND AMERICAN PARTICIPATION IN THE WAR, by HORACE W. STUNKARD, LOWELL T. COGGESSHALL, THOMAS T. MACKIE, ROBERT MATHESON, AND NORMAN R. STOLL. Annals of the New York Academy of Sciences, Volume XLIV, Art 3. Pages 197–261. Sept. 30, 1943. Published by The New York Academy of Sciences, Central Part West at Seventy-ninth Street. Price $1.00.

This publication consists of five papers on parasitic diseases as related to America's participation in the war. They were read in March, 1943, at a conference called by the Section of Biology of The New York Academy of Sciences. The titles and authors are as follows: Introduction to the Conference on Parasitic Diseases, by Horace W. Stunkard; Current and Post-War Problems Associated with the Human Protozoan Diseases, by Lowell T. Coggesshall; Changed Viewpoints on Helminth Diseases, by Norman S. Stoll; and Arthropods as Vectors of Human Diseases with Special Reference to the Present War, by Thomas T. Mackie. Each paper carries a short bibliography together with a discussion which followed its presentation. The subject matter is up-to-date and well balanced.

The dispersal of American troops to tropical areas of the world has done much to focus attention upon the importance of parasitic diseases. In their papers, two of the authors, Coggesshall and Stoll, discuss the reservoirs of possible infections in native populations among which our troops are stationed. The importance of arthropods as vectors of parasitic diseases is stressed throughout the publication. The paper by Matheson carries tables of the species of mosquitoes known to transmit malaria, yellow fever and filariasis throughout the world. The recognition accorded parasitic infections by the medical personnel of the armed forces and the part these diseases play in military campaigns is reviewed by Thomas Mackie. He points out that the application of information gained through research, largely since the last war, has prevented our armies from being immobilized by malaria and dysentery.

We are warned that problems of parasitic diseases will not cease with the end of the war. Soldiers with latent and chronic infections will become scattered over the United States after their demobilization. Whether or not some of these tropical parasites may be able to find new intermediate hosts and establish themselves in suitable areas of the United States is a problem about which we need more information.

Several of the authors suggest measures to meet current and post-war problems of parasitic diseases. Thomas T. Mackie suggests ". . . the inclusion of much more parasitology and tropical medicine in the curricula of our medical schools." Horace W. Stunkard adds to this the immediate ". . . organization and establishment of a center for the investigation of parasitic diseases." European countries, with colonial interests, have long recognized the importance of parasitic infections. This is reflected in the strong departments of parasitology, museums, and teaching collections, in their educational institutions. In this respect we have lagged far behind. It appears that the time is near at hand for an expension of the field of parasitology in the United States.—W. M. TIDD.

BIONOMICS OF AMAPSOCUS AMABILIS (WALSH)

(Corrodentia, Psocidae)[1]

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The generic name *Pseudopsocus* Chapman 1930 (1) is preoccupied by *Pseudopsocus* Kolbe 1882 (2); therefore a new name, *Amapsocus*, is here proposed for Chapman's name since it is quite distinct from Kolbe's *Pseudopsocus*.

Amapsocus, new name

Pseudopsocus Chapman (1) 1930, p. 287. Genotype, by original designation, also monobasic.—*Psocus amabilis* Walsh. Preoccupied.

Amapsocus amabilis (Walsh) is the only species of this genus thus far found in the United States. It is also the only representative of the family Psocidae that has been found on corn during this work. It has previously been recorded from New York, Illinois, Tennessee and Virginia from July to October, with most records about the middle of September. During this work adults and eggs were taken on dried leaves at Mt. Carmel, Connecticut, in October and from dried leaves of oak, maple, buckeye, elm and chestnut-oak during September, October and November in Illinois. Eggs, nymphs and adults were collected on dried corn stalks in a field at Urbana, Ill., June 9 and 19. Eggs were taken from standing corn at Glen Ellyn, Ill., March 14.

Complete descriptions of the adults can be found in the paper by Chapman (1). Reared adults (figs. 1 and 2) were a little smaller than the measurements given by Chapman, probably because they were reared in the laboratory and did not always have an abundance of food.

Of the forty-two species in the family Psocidae reported from the United States, *A. amabilis* is one of twenty-six for which both sexes are known. Males and females were produced in about equal numbers in the laboratory.

Mating.—The male apparently sensed the female while still a few millimeters from her. He approached flitting his wings rapidly, then followed along the side of her body until coming to the end of her wings, ran up on top of them and remained poised there for a few moments. He darted down over the front of her head and backed underneath her with his wings held butterfly-fashion. While she

[1]Contribution No. 238 from the Entomological Laboratories of the University of Illinois. This paper was included as a part of a thesis submitted in partial fulfillment of the requirements for the Degree of Master of Science in Entomology in the Graduate School of the University of Illinois, 1941. I wish to express my appreciation of the suggestions made by Professors C. L. Metcalf and W. V. Balduf during this work. Thanks are also due Dr. A. B. Gurney, of the U. S. Bureau of Entomology and Plant Quarantine, for determinations of the species concerned.

grasped the posterior margins of his wings with her anterior tarsi she was raised to about a 60° angle. The genitalia were fused about fifteen seconds (the female directly above the male), then she turned, detached herself and paid no further attention to his attempts to regain the mating position. For some time the male continued to flit his wings and tried to climb on the female's back. In three instances just after mating the fertilized females were taken out and virgin females put in the rearing tubes, but the males paid no attention to the virgins.

Oviposition.—In the field, eggs have been found on the inner surface of the corn leaf sheaths. The eggs were laid in groups of from one to twenty-two, but most commonly in masses of seven or eight and three or four. The last were often found and were probably laid by young females, or by individuals already on the decline.

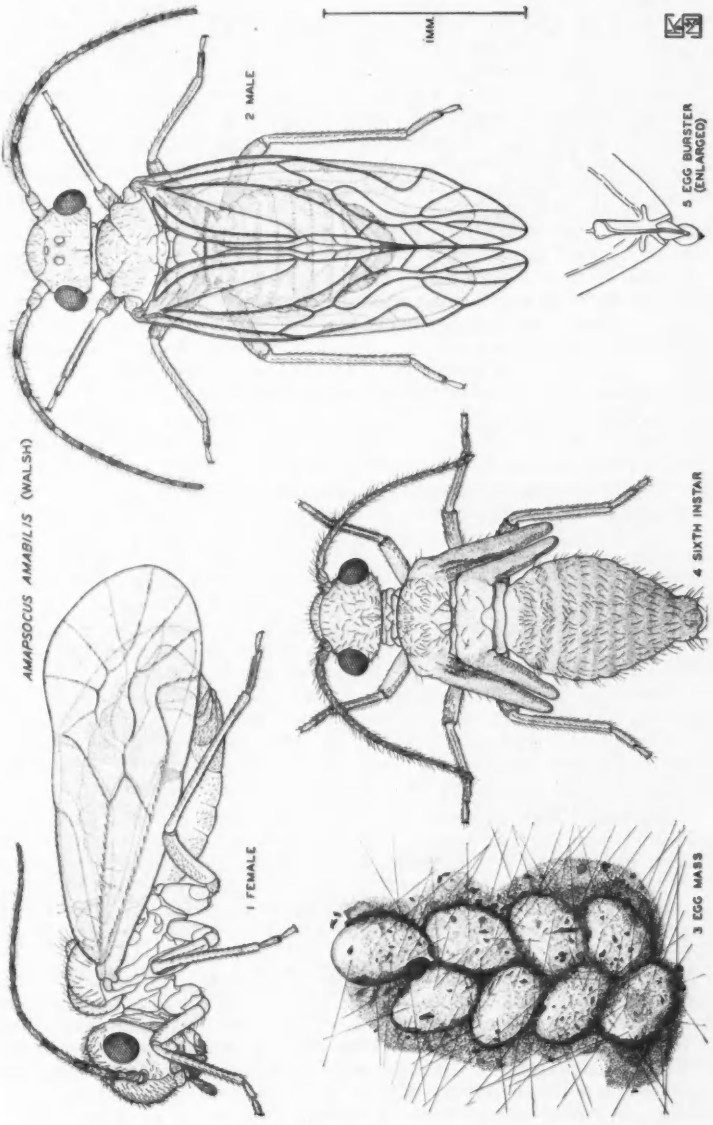
Egglaying started from two to four days after moulting to the adult, and continued four to thirteen days. Eggs were not always deposited each day. Young females usually deposited only three or four eggs in the first group whereas the number per group averaged seven or eight during the peak of oviposition, until it dwindled again to one at the end. Small masses sometimes occurred during the middle of the oviposition period. The egg mass (fig. 3) usually consisted of two rows of eggs, the individual eggs being placed herringbone fashion. Adults, collected in the field and put in individual rearing tubes, deposited eggs on the sheath two-thirds of the time, and on the glass the other third. Those reared from eggs in individual tubes reversed the situation, depositing them on the glass two-thirds of the time, and on the sheath the remainder. The smooth glass was something new to the adults collected in the field; so they followed their old custom of laying eggs on the corn. It might be explained that those reared from the eggs in the glass tubes had become accustomed to the smooth glass surface so did not avoid it. Eggs were never deposited on the cotton plugs, as they were in the case of *Lachesilla nubilis* (7).

The number of egg masses per individual ranged from three to twenty-one, with eleven, twelve and thirteen being most common. Sometimes three or four small groups were laid in one day, but usually one mass of seven or eight a day seemed the rule when food was fairly abundant. The maximum number of eggs deposited by any one individual was one hundred and fifteen. Abundance of food apparently affected the maturing eggs because more were laid after fresh pieces of sheath were put in the tubes. Death occurred from one to six days after oviposition ceased.

The actual process of oviposition followed the same sequence as that described for *Caecilius manteri* (5) and *Ectopsocus pumilis* (6). The female ran up and down over a small section of the corn sheath. She appeared to be touching the sheath with her labium, much in the same fashion as *L. nubilis* when it attached strands of silk to the corn. Then she touched her abdomen to the corn sheath as if trying to scrape something off by dragging it a short distance. She suddenly stopped and remained perfectly still. A drop of liquid appeared and the abdomen was touched to the sheath. After violent trembling, which lasted about a quarter of a minute, she lifted her abdomen, leaving the egg on

Amapsocus (Psocidae)
Kathryn M. Sommerman

PLATE I



the sheath with the liquid around it. The drop of liquid quickly soaked in. Then for another twelve minutes she nibbled about, up and down on the sheath, until the second egg appeared, and was completely laid in one minute, alongside the first. After nibbling for seventeen minutes the third egg was laid in one-half minute. Twenty-four minutes later the fourth appeared and it was deposited in one and a half minutes. This particular group (fig. 3) finally contained nine eggs; so it is assumed that it required at least two hours to complete the mass, because it took fifty-six minutes to lay the first four.

When the last egg had been laid the female scattered strands of silk across the eggs and attached them to the substratum. Incompleted masses were not at first so darkly covered with granular particles as they appeared to be on the day following the completion of oviposition. For that reason, although it was not observed, there is a possibility that the females deposit on the egg masses a fluid from the anus, similar to *Ectopsocus californicus* (Banks), which has been observed depositing eggs on pieces of corn sheath in the culture tubes. "Daubing" by *E. californicus* has also been reported by McClure (3).

Egg Stage.—The eggs are ovate, being slightly larger toward one end. The surface that adheres to the substratum is flat and wrinkled, while the entire curved surface is smooth and shiny. The average length of ten eggs chosen at random was 0.478 mm. and the width 0.324 mm. The eggs are white when first laid, but turn cream-colored as development progresses. The egg mass (fig. 3) shows how a group of eggs (laid on the glass) appears with transmitted as well as reflected light. The masses are densely covered with granular material making it impossible to see the outline of the individual egg by reflected light alone. On the corn sheaths the masses are inconspicuous to the naked eye, appearing like a spot of dirt or fungus sclerotium. Pellets of excrement are often deposited on the egg masses, further concealing them.

There are no evident signs of embryonic development when the eggs are deposited on the sheaths. When the eggs were laid on the glass where the ventral side could be seen, the eyes of the embryo showed through the eggshell the day before hatching. Hatching usually occurred eight days after the eggs had been deposited.

Hatching.—Hatching was observed in part once and this particular individual happened to be the last one of the group to emerge. The nymph was already in a perpendicular position, almost completely free from the pronymphal membrane. The egg burster (fig. 5), which lies across the front of the head underneath the pronymphal membrane and attached to it, is wishbone-like in shape with an elongate central shaft having a sharp center ridge terminating in a pointed process with another "knob" projecting beneath it. The central portion and the arms are transparent, the only dark parts being the tips of the two knobs at the extremity of the burster. The pronymphal membrane cast at hatching was found several times entirely free from the eggshell. This suggests that either the pronymph completely freed itself from the eggshell before the membrane split, or perhaps the nymph had difficulty freeing the tip of the abdomen from the membrane; so dragged it a short distance from the egg as it walked away.

Postembryonic Development.—The nymphs (fig. 4, sixth instar) are buff, gradually becoming light brown, with no indications of markings, but are very shiny with conspicuous bristly setae on the abdomen. This shiny condition is more pronounced when the alimentary canal is black with food. The antennae are eight-segmented in the first instar and thirteen-segmented thereafter. Wing-pads appear in the third instar and approximately double their length with each successive moult. The duration of the six instar periods was as follows: first, 2.4 days; second, 2.3 days; third, 2 days; fourth, 2.4 days; fifth, 2.8 days, and the sixth, 3.4 days. Similar to *Caecilius manteri* (5), *Ectopsocus pumilis* (6) and *Lachesilla nubilis* (7) the last instar period is longer than any of the others. The averaged measurements in the following table were taken from living specimens, seven to fifteen individuals per instar.

Instar	First	Second	Third	Fourth	Fifth	Sixth	Adult
	mm.	mm.	mm.	mm.	mm.	mm.	mm.
Head width	0.225	0.270	0.349	0.414	0.499	0.584	0.602
Body length	0.726	0.886	1.092	1.192	1.565	1.796	2.472
Forewing length	.....	.....	0.120	0.220	0.407	0.728	1.953

The complete nymphal period required fourteen to eighteen days. The adult stage lasted about fourteen days. The total length of all the life stages was about thirty-seven days.

Moulting.—In most cases the nymphs ate the exuviae. The majority of the exuviae that were found were in a vertical position with the head down. Moulting was similar to that observed in the three species previously referred to. The epidermis split along the head and thorax, and the nymph arched up with the antennae held back along the sides of the body. Freeing the head, the nymph gradually rose until it was actually resting on the end of the abdomen. Air bubbles were being swallowed causing the abdomen to lengthen. The antennae and legs were released when it had risen to a vertical position. After exercising the legs and antennae the nymph bent over and stood beside the exuviae. Later the abdomen contracted to its normal length and feeding occurred shortly.

Habits.—While under laboratory conditions the nymphs and adults eat fungi, corn sheaths and exuviae. Silk is spun by nymphs and adults but it is not noticeable. This species reacted to moisture the same as *C. manteri, L. nubilis* and *E. pumilis.* They sunk their mandibles into the moist cotton plugs and readily drank the water. After a suitable rearing technique was worked out [Sommerman (4)] it was very easy to raise this species because it ate not only the fungus growths but the corn sheaths too.

Overwintering.—Eggs found in the field March 14, 1941, were brought into the laboratory where they all hatched. The nymphs were successfully reared to adults for positive determination. Healthy eggs found in the field at that time of the year suggest that the winter is passed in the egg stage in Illinois.

Summary.—Adults and eggs of *Amapsocus amabilis* have been taken from Connecticut, New York, Virginia, Tennessee and Illinois. Both sexes are known and the sex ratio is about 0.5. The individual eggs are white when first laid and turn cream-colored as development progresses, but the egg mass as a whole appears dark because the eggs are covered with a granular material and with excrement. The eggs are deposited in groups and are covered with a loose network of silk. Hatching occurs eight days after the eggs have been laid. The antennae are eight-segmented in the first instar and thirteen-segmented thereafter. The wing-pads appear on the third instar and the forewings about double their length with each successive moult. During moulting the nymphs are in a vertical position with their heads down. The nymphal period requires fourteen to eighteen days and the adult stage lasts about fourteen days. The usual life span, including the period within the egg, is about thirty-seven days. The nymphs and adults feed on the various parts of the dried corn plants and the fungi growing there, and they usually consume their exuviae. In the more northern states where this species is found winter is passed in the egg stage.

LITERATURE CITED

(1) **Chapman, P. J.** Corrodentia of the United States of America: 1. Suborder Isotecnomera. Journ. New York Ent. Soc., Vol. 38, pp. 219–290, 319–430. 10 pls. 1930.

(2) **Kolbe, H.** *Pseudopsocus rostocki* n. sp. Entomologische Nachrichten (Katter: Stettin), Vol. 8, p. 209.

(3) **McClure, H. E.** Psocid Habits. Ent. News, Vol. 47, pp. 113–118, 143–146. 1936.

(4) **Sommerman, K. M.** Rearing Technique for Corrodentia. Ent. News, Vol. 53, pp. 259–261. 1942.

(5) ——. Description and Bionomics of *Caecilius manteri* n. sp (Corrodentia). Proc. Ent. Soc. Washington, Vol. 45, No. 2, pp. 29–39, 2 pl. Feb., 1943.

(6) ——. Bionomics of *Ectopsocus pumilis* (Banks): (Corrodentia, Caeciliidae). Psyche, Vol. L, Nos. 3–4, pp. 53–64, 2 pl. Sept.-Dec., 1943.

(7) ——. Bionomics of *Lachesilla nubilis* (Aaron): (Corrodentia, Caeciliidae). Can. Ent., Vol. LXXV, pp. 99–105, June, 1943.

CARBONIFEROUS INSECTS FROM THE VICINITY OF MAZON CREEK, ILLINOIS, by F. M. CARPENTER. Illinois State Museum (Springfield, Illinois), Scientific Papers, vol. III, Part 1: 9–20, 4 pls.

"The ironstone nodules occurring near Mazon Creek, Illinois, are the most important source of Carboniferous insects in North America. Although actually rare in the nodules about 150 specimens have been found during the past 78 years. . . . All nodules in the Langford collection were found at the strip mine of the Northern Illinois Coal Corporation, only a few miles from Morris. The Francis Creek shales, which yield the nodules are part of the Carbondale group (Upper Carboniferous). The Mazon Creek insects are older than those of the famous Commentry shales in Central France."

The Mazon Creek beds are one of the most important collecting spots in the world, for specimens of the earliest types of winged insects. The few fossil insects from this area have been studied and restudied by students of the early history of the Insecta. Handlirsch of Vienna studied them in 1906, and again in 1911 when he gave these few fossils a special publication, "New Paleozoic Insects from the Vicinity of Mazon Creek, Illinois," 80 pages, 63 figures.

Five insects of the Paleodictyoptera and the Protorthoptera are described by Carpenter.—C. H. K.

OBSERVATIONS ON COMPERIELLA BIFASCIATA, AN ENDOPARASITE OF DIASPINE COCCIDS[1]

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The encyrtid *Comperiella bifasciata* How. is of interest primarily as a parasite of the citrus scale insects *Aonidiella citrina* (Coq.) and *A. aurantii* (Mask.). Introduced and established in California by the University of California Citrus Experiment Station in 1924, under the direction of Professor H. S. Smith, in an unsuccessful attempt to control *A. aurantii*, *C. bifasciata* proved to be of considerable value in reducing the frequency of infestations of *A. citrina* on citrus in southern California (Smith, 1942). Because of the economic importance of *C. bifasciata* and the recent discovery that the species consists of at least two host-determined races, it seems advisable to record the biological observations made during the past two years. Compere and Smith (1927) and Ishii (1932) present biological data in relation to hosts other than *A. aurantii*.

The genus *Comperiella* appears to be oriental in origin. Three unquestionably distinct species are known: *C. indica* R. A., reared from *Aspidiotus tamarindi* in India (Ayyar, 1934); *C. unifasciata* Ishii, a uniparental species, reared from *Aspidiotus destructor* in Java and from *Pseudaonidia duplex* in Japan (Taylor, 1935); and *C. bifasciata*, a biparental species, recorded from Australia, Java, China, Japan, India, and Mauritius (Flanders, 1934; Gahan, 1927; Silvestri, 1929; Glover, 1935; and Moutia, 1934).

The host genus *Aonidiella* appears to be Ethiopian and oriental in origin (McKenzie, 1938); the host genus *Chrysomphalus* appears to be Australian and Indo-Malayan in origin (McKenzie, 1939).

Comperiella bifasciata has been reared from *Aonidiella eremocitri* McK. by the writer. It is a common parasite of *A. taxus* Leon. in Japan and of *A. orientalis* (Newst.) in India. It commonly attacks the yellow scale, *A. citrina*, throughout its range in Japan, China, and India, but is known to attack the red scale, *A. aurantii*, only in China, although both occur together elsewhere. *C. bifasciata* commonly attacks *Chrysomphalus dictyospermi* (Morgan) in Central China and *C. bifasciculatus* Ferris in China, from Shanghai to Peking.

The red scale has wider distribution and exists under more varied conditions than the other hosts of this parasite.

In 1922, a colony of *Comperiella bifasciata* from *Aonidiella taxus* sent to California from Japan was placed on *A. aurantii*, but only 1 male parasite was reared (Smith, 1923). As a result of additional shipments made from Japan in 1925, *C. bifasciata* was established in California on

[1]Paper No. 513, University of California Citrus Experiment Station, Riverside, California.

Chrysomphalus bifasciculatus and on *A. citrina*. In 1936, Bess[2] recorded the rearing of 20 males and 10 females of this Japan race from scales that were questionably red scale. In 1932, Compere[3] found, experimentally, that *C. bifasciata* reared from yellow scale on citrus at Poona, India, would not reproduce in red scale grown on citrus at Coonoor, India; it is therefore possible that the Japan race occurs in India.

In 1941, a stock of *Comperiella bifasciata* was obtained in China, from *Aonidiella aurantii* on citrus. This race reproduced abundantly on *A. aurantii* in the insectary at the University of California Citrus Experiment Station; in fact, over two million parasites were reared within fifteen months after introduction. Reproduction of this China race has also occurred to a limited extent in the field in California, but establishment is yet uncertain, and there is no indication that it is able to control red scale.

LABORATORY STUDIES OF THE HOST-DETERMINED RACES OF COMPERIELLA BIFASCIATA

The Japan and China races of *Comperiella bifasciata* readily interbreed. When reproduced on red scale, the progeny of the reciprocal crosses are equal in sex ratios but markedly unequal in numbers. The reproductive capacity of the females of either race in red scale is unchanged by cross-mating.

Maximum production of the China race (136 offspring per female) occurred when second-instar hosts were exposed to parasitization. There is considerable evidence that such hosts should be feeding on plant fruits having a certain degree of maturity, in order to insure optimum conditions for the development of the larvae of *Comperiella bifasciata*.

After the condition of red scale most satisfactory for maximum production of *Comperiella bifasciata* had been ascertained, females of the Japan race[4] were provided with an abundant supply of such red scale. Surprisingly, an average of 2 offspring per female was obtained.

The fecundity of the China race was found to be about twenty-five times that of the Japan race when the latter was propagated on red scale. (Both races are about equal in fecundity when reproducing on yellow scale.) This difference holds true with unmated females as well as with cross-mated females and is therefore a maternal effect.

As stated by Dobzhansky (1941: 88–89): " . . . an egg is an organized system which represents the result of a long process of development in the ovary of the mother. The structure, and hence to a certain extent the potentialities, of the egg had been determined before fertilization by the genes in the nucleus of the growing oocyte. . . . The characteristics of the development which sets in after fertilization by a sperm of a foreign

[2]Bess, Henry. Unpublished notes on file at the University of California Citrus Experiment Station, Riverside.

[3]Compere, Harold. Unpublished notes on file at the University of California Citrus Experiment Station, Riverside.

[4]In order to be certain that the females of the Japan race were of pure stock, they were obtained from yellow-scale material collected in Tulare County, California, and shipped to the writer by the County Agricultural Commissioner, Oscar L. Hemphill.

species need not be due to the gene complex present in the egg at that particular time; they may have been predetermined much earlier by the maternal genotype. . . [Such a predetermination has been] observed in many intraspecific, as well as interspecific, crosses, and is usually described as a 'maternal effect.'"

The failure to rear the Japan race in red scale, prior to the present work, appears to have resulted from the use of fruit from the field, which was infested with a high proportion of scales unsuitable for the small proportion of eggs inherently able to hatch in red scale. Preliminary tests have shown that the capacity of the Japan race to reproduce in red scale is not increased by breeding from individuals that have developed in red scale.

TABLE I

RESULTS OF FECUNDITY TESTS WITH THE TWO RACES OF *Comperiella bifasciata* How., SHOWING A MATERNAL EFFECT THROUGH PROPAGATION ON RED SCALE

Test No.	Parentage	Number of Female Parasites Used[5]	Number of Offspring	
			Average Per Female	Maximum Per Female
1	China Female × China Male.....	8	50	136
2	China Female, Unmated.....	10	41	114
3	China Female × Japan Male.....	100±[6]	47[6]	...
4	F_1 Female (From China Female × Japan Male), Unmated.....	9	2	7
5	Japan Female × Japan Male.....	12	2	10
6	Japan Female, Unmated.....	20	2	6
7	Japan Female × China Male.....	20	< 1	4

[5]Unless otherwise specified, in these tests one female parasite was used for each red-scale-infested fruit.

[6]The average of three tests, in each of which 100± female parasites were used for every 6 to 8 red-scale-infested fruits.

In the present study, the parasites were segregated according to their sex, while in the pupal condition and before they emerged from their hosts. Grapefruit and lemons artificially infested with red scale were used for rearing the offspring. All the scales on a single fruit were the same age. The rearings occurred at temperatures about 80° F. At this temperature the average life of an adult female parasite is about 10 days, a period which equals the duration of the second instar of the red scale.

Results of racial fecundity tests in which each individual female parasite was confined, during its adult life, to a single fruit infested with second-instar red scale, are shown in Table I.

In mass tests, in each of which approximately 100 mated females were confined, during their adult life, to 6 or 8 grapefruit infested with second-instar red scale, results were as follows: When China females were mated with Japan males, in three tests, the offspring per female *averaged* 51, 43, and 46, respectively. When Japan females were mated

with China males, in three tests, the *total* offspring of all females were 35, 43, and 51, respectively.

DEVELOPMENT OF COMPERIELLA BIFASCIATA IN RED SCALE

When the red scale and the China race of *Comperiella bifasciata* are reared in the laboratory at a constant temperature of about 80° F., the scale reaches maturity in about 38 days, and the parasite in from 20 to 40 days. The rate of parasite development varies with the developmental condition of the scale at the time of attack. Parasite development is most rapid when the host is in the early third instar and slowest when the host is in the early first instar. The emergence of adult *Comperiella* from scales attacked at any one time may extend over a period of from one to two weeks. Under field conditions in southern California, the minimum life cycle of the parasite, during the summer, is about 30 days in the vicinity of Riverside, 40 days at Anaheim, and 50 days at Chula Vista.

Comperiella bifasciata, unlike many encyrtids, deposits the entire egg within the host. The incubation period of the egg, at 80° F., is 4½ days. The larval period of the parasite consists of five instars. In the minimum life cycle of 21 days (host in early third instar), the first instar of *Comperiella* is 3 days; the second, third, and fourth instars together, 3 days; the fifth instar, 4 days; and the pupal period, 7 days. In the life cycle of 38 days (egg in early first-instar host), it is probable that the first parasite instar extends to 15 days or more.

Embryonic development is unaffected by the host. Larval development, however, during the first instar may be greatly prolonged by the host, the rapidity of parasite development varying with the stage of the host at the time of attack. Development of the parasite during the second instar is affected by the host, but to much less extent. The first instar larva may molt once or twice before the second instar begins.

The development of the host is retarded if it is attacked during the first and early second instars. In such cases the parasite emerges early in the third instar of the host, during the gray stage, rather than later. When scales in the first instar are exposed to attack, the parasites oviposit and their progeny complete their development in both sexes of the host. Male scales, however, are apparently successfully parasitized only when the egg is deposited in the first instar. No parasite eggs have been found in male pupae.

Approximately one-half of the progeny of mated female parasites are female, except when mature hosts are attacked; then females predominate. This may be an effect of the increase in time required for oviposition in mature hosts: the longer the period between ovipositions, the greater the opportunity for the egg to be fertilized and, consequently, become female (Flanders, 1939).

When a mated female is withheld from its host for 2 or 3 days before being allowed to oviposit, it oviposits for several hours at the rate of approximately 3 eggs per hour. The maximum number of progeny obtained from any one mated female was 136, with sexes equal in numbers. These developed from eggs deposited over a 20-day period.

One unmated female produced 114 male progeny. At temperatures of about 80° F., the average life of an adult female parasite is about 10 days, but females not allowed to oviposit may live for 30 days. The average number of adult progeny per female is about 50. There may be considerable superparasitism resulting in a wastage of eggs.

Hosts attacked when in the second instar yield the greatest proportion of parasite progeny. Oviposition by the parasite occurs most readily in hosts of this instar, and there is less mortality of either host or parasite than in the first or third instars.

BEHAVIOR OF THE ADULT PARASITE

The adult female parasite sometimes feeds on the body fluids of young male and female scales. This is done through wounds made with the ovipositor for the purpose of such feeding. The female may insert its ovipositor through the same wound several times, relocating it by means of the mouthparts and ovipositor sheaths.

When reared on infested grapefruit under insectary conditions, the parasitized scales occur, for the most part, on the ventral half of the fruit, possibly because the female parasites frequent ventral surfaces. (In this connection it is interesting to note that, in the case of the yellow scale on leaves of citrus, the male scales predominate on the upper surfaces, and the female scales on the under surfaces.)

Attraction between the sexes of *Comperiella* is not marked. The number and frequency of contacts between the sexes, before mating occurs, is unusually high. The sexes remain in copulation about 5 seconds. Between periods of oviposition, the females are positively phototropic when the light intensity is increasing and negatively phototropic when the light intensity is diminishing. Females are capable of ovipositing the day they emerge from the host. They are not readily disturbed after oviposition begins. At temperatures below 56° F., the adults are sluggish.

The stimulus for exerting the ovipositor and drilling seems to be produced only by the scale exudation or covering, the ovipositor often being inserted in exuviae of male scale. Much effort is therefore wasted in locating suitable hosts. This habit in such a short-lived species greatly reduces its host-finding capacity, particularly when dead hosts remain on the host plant.

STRUCTURAL AND PHYSIOLOGICAL CHARACTERISTICS

The egg of *Comperiella bifasciata* is stalked but bears no aeroscopic plate; it is accordingly deposited free in the body cavity of the host. The chorion of an egg that fails to hatch becomes thickened, leathery, and brown in color when deposited in red scale. The reddish accretions which sometimes form in the blood of scales that have been attacked may be mistaken for shrunken, dead eggs.

The most noticeable structural differences in the different larval instars of the parasite are in the form of the mandibles and in the ramifications of the tracheal system. The mandibles of the first instar point anteriorly rather than laterally or posteriorly. Ishii (1932) states that

they point "upward." The mandibles of the second instar are typical, except that the extreme tip of each is bent anteriorly. The mandibles of the other instars are entirely typical. The respiratory system is typical, spiracles appearing only in the fifth instar.

The mid-gut of *Comperiella* is noteworthy in that its contents indicate a urinary as well as a digestive function. This double function is to be expected in chalcid larvae in their early instars, since they lack Malpighian tubules. The contents of the mid-gut of *Comperiella* larvae developing in species of *Aonidiella* include one or more crystalline rods (fig. 1), which may become so long that the mid-gut is ruptured. These rods remain intact in normal salt solution but dissolve instantly in acetic acid. Crystalline structures appear to be absent in the gut of *Comperiella* larvae that develop in *Chrysomphalus bifasciculatus*.

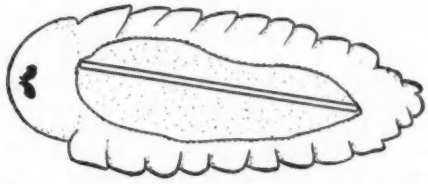

FIG. 1. First-instar larva of *Comperiella bifasciata*, showing position of crystalline rod in mid-gut.

SUMMARY

Comperiella bifasciata How., in its relation to the red scale, *Aonidiella aurantii* (Mask.), consists of two host-determined races. One race is able to reproduce for generations on the red scale; the other race is unable to do so because of its low fecundity when *A. aurantii* is its host. The capacity to develop in *A. aurantii* is shown by cross-breeding to be a maternal effect. The rate of development of *C. bifasciata* during its first instar varies with the developmental condition of the host at the time of attack. The female host is susceptible to successful parasitization in all its instars; the male host, only in the first instar. *C. bifasciata* is most successful when it attacks its host in the second instar. The minimum life cycle of the parasite is 21 days at 80° F. The sexes are approximately equal in numbers. One or more crystalline rods in the mid-gut of the developing larva of *C. bifasciata* indicate a urinary function of the mid-gut.

LITERATURE CITED

Ayyar, T. V. R. 1934. First record of the chalcid genus *Comperiella* Howard from India, with a description of a new species. Indian Mus. Rec., 36: 219–21.

Compere, Harold, and **Smith, H. S.** 1927. Notes on the life-history of two oriental chalcidoid parasites of *Chrysomphalus*. California Univ. Pubs. Ent., 4: 63–73.

Dobzhansky, Theodosius. 1941. Genetics and the origin of species. 2d ed. 446 p. Columbia University Press, New York, N. Y.

Flanders, S. E. 1934. Insects on rutaceous trees native to subtropical Australia. Pan-Pacific Ent. 10: 145–50.
1939. Environmental control of sex in hymenopterous insects. Ent. Soc. Amer. Ann. 32: 11–26.
Gahan, A. B. 1927. On some chalcidoid scale parasites from Java. Bul. Ent. Res. 18: 149–53.
Glover, P. M. 1935. An account of the occurrence of *Chrysomphalus aurantii* Mask. and *Laccifer lacca* Kerr. on grapefruit in Ranchi District, Chota Nagpur, with a note on the chalcidoid parasites of *Aspidiotus orientalis* Newst. Bombay Nat. Hist. Soc. Jour. 38: 151–53.
Ishii, Tei. 1932. The Encyrtidae of Japan. II—Studies on morphology and biology. Imp. Cent. Agr. Exp. Sta., Japan, Bul. 3: 161–202.
McKenzie, H. L. 1938. The genus *Aonidiella* (Homoptera; Coccoidea; Diaspididae). Microentomology 3: 1–36.
1939. A revision of the genus *Chrysomphalus* and supplementary notes on the genus *Aonidiella* (Homoptera; Coccoidea; Diaspididae). Microentomology 4: 51–77.
Moutia, A. 1934. Mauritius Dept. Agr. Ann. Rpt., 1933.
Silvestri, F. 1929. Preliminary report on the citrus scale-insects of China. 4th Internatl. Cong. Ent. 2: 897–904.
Smith, Harry S. 1923. Biological control work. California Dept. Agr. Monthly Bul. 12: 334–42.
1942. A race of *Comperiella bifasciata* successfully parasitizes California red scale. Jour. Econ. Ent. 35: 809–12.
Taylor, T. H. C. 1935. The campaign against *Aspidiotus destructor* Sign. in Fiji. Bul. Ent. Res. 26: 1–102.

HOW TO COLLECT AND PRESERVE INSECTS, by H. H. Ross. Natural History Survey Division Circular 39 (Second Printing, with Additions), May, 1944. Pages 1–55, 63 figs.

This helpful manual is apparently used by the Survey to instruct amateur collectors who are willing to collect for the state collections. As the Survey is in the Department of Education it can rate as a supplementary text in biological courses.

It covers: Where to Collect; What to Use; Special Collecting Equipment; Sending Insects for Identification; How to Handle Unmounted Specimens; How to Mount and Preserve Specimens; How to Label; Housing; Identifying the Specimens; Relatives of Insects; the State Insect Collections; How to Ship; Reports on Illinois Insects; Useful Books; Where to Buy Supplies.—C. H. K.

A REVISION OF THE EMBIOPTERA, OR WEB-SPINNERS, OF THE NEW WORLD, by EDWARD S. ROSS. Proc. U. S. Nat. Mus. 94: 401–504, pls. 18, 19. 1944.

Seventy-one species are described in seventeen genera and six families. Except for Oligotoma, three species introduced, all genera seem to be endemic to the New World. The new species are figured by a total of 156 good line drawings. Species can be determined positively only on the mature male genitalia which have to be treated with KOH and mounted on glass slides. Females and immature forms lack specific characters. Such procedure avoids the use of "weasel words," larger, smaller, denser, etc.

Latin descriptions beginning with Linnaeus in 1758 were well cleared up by 1830. Then followed descriptions in modern languages with the gradual recognition of the impossibility of an exact terminology, a clouded taxonomy now in question. By 1900 the necessity of exact illustrations had become appreciated, and since the work on Drosophila, genetic studies have come into the picture. (See p. 365.) In the ants physiological evolution has outdistanced morphological. Name a physiological species! We appreciate figures in this paper by E. S. Ross.—C. H. K.

THE FEMALE OF AESHNA RUFIPENNIS

(Odonata: Aeshnidae)

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In these Annals, June, 1941, pages 397–403, I described the male of *Aeshna rufipennis*, n. sp. from Satipo, in the Urubamba Valley of Peru. Shortly after its publication a female and seven more males were received from the collector, Pedro Paprzycki. The female was dated May 23, 1940. One male was undated; six bore the dates May 24, 29, June 3 (2 specimens), 9 and 20, 1940.

The only known female Aeshna that this might be confused with is that of *luteipennis* Burm. She is probably the female of *rufipennis* because: 1, *luteipennis* has not been recorded from that area; 2, the female was shipped with seven males of *rufipennis*; 3, all eight specimens were labeled "Satipo" and, 4, all were dated from May 23 (the female) to May 24–June 20 (seven males).

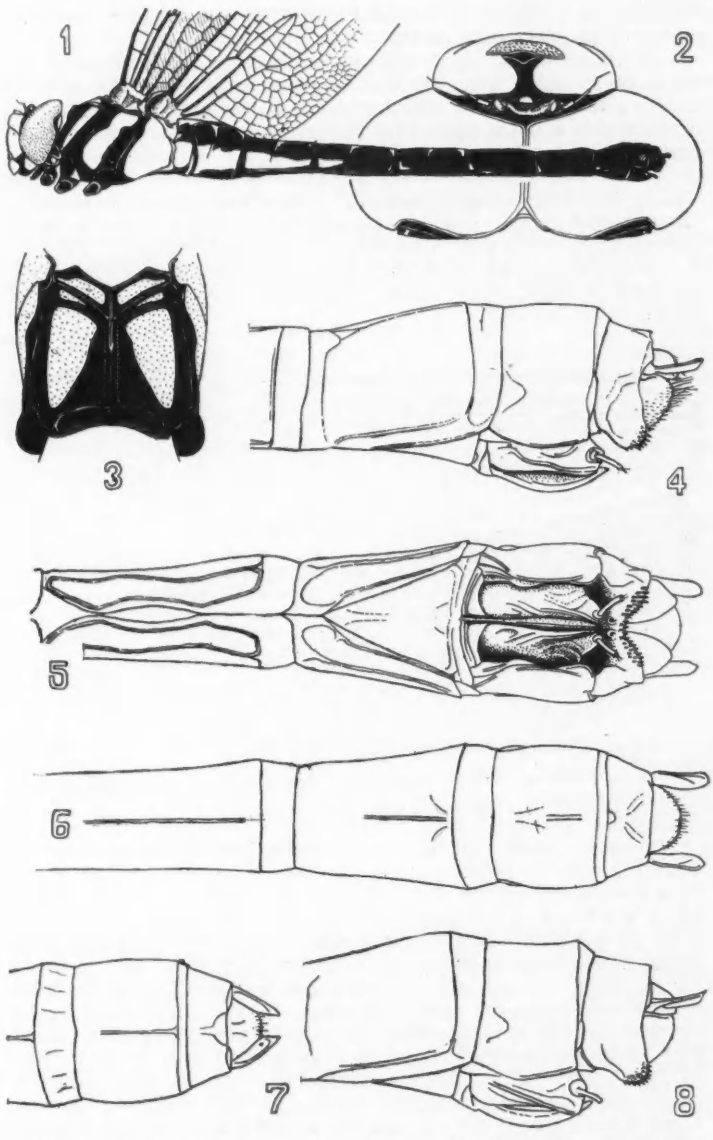
Rufipennis has a long season, if it is not on the wing the year around. The four males of the earlier description were dated from Nov. 26 to Dec. 27, 1940. These are from May 24 to June 20, 1940, actually collected by Paprzycki previous to the earlier shipment. Three have clear wings. In none are the wings frayed. In none of the four November and December males were the wings frayed nor were they heavily browned as in aged Gynacanthas. The dates of collection, if correct, and the condition of wings suggest a continuous around-the-year flight as in *Anax junius* but seldom found, if at all, in Aeshna. Calvert (Biol. Cent. Amer., p. 187, 1905) does not give dates for the close relative, *luteipennis*.

Aeshna rufipennis Kennedy, female, allotype

Figs. 1–6

Length of abdomen 61.5 mm. including appendages which are 1.5 mm.; hind wing 50 mm. long and 14 mm. wide before level of nodus. Stigmas 4.2 mm.

Labium chestnut shading into olive gray on its base; mandibles yellowish shading into chestnut towards the teeth, the pleurostoma black; labrum reddish shading into yellow on the lateral lobes; anteclypeus olive green, postclypeus and vertical surface of frons a medium olivaceous brown with the lateral surfaces of both greenish next the eyes, this green area on either side connected across the horizontal surface of the frons; the T-spot with a broad V-shaped stalk, its narrow base widening around the middle ocellus; vertex, its sulcus and the antennae black, except a minute pale speck entad of each lateral ocellus. The fronto-clypeal suture across the face with a brown hair-line narrowly edged with dull yellow. Rear of

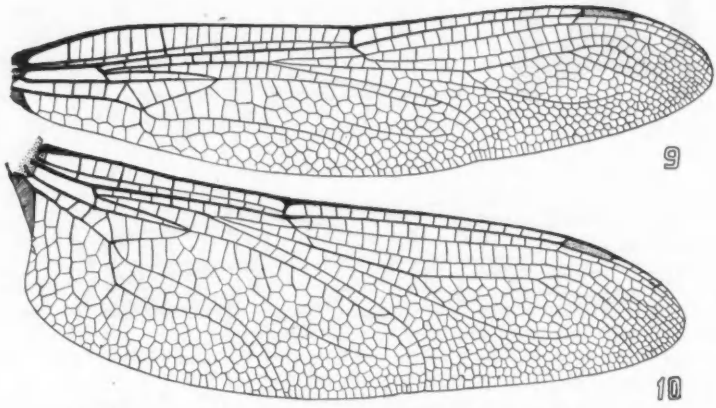


FIGS. 1–6. The allotype female of *Aeshna* (*Coryphaeschna*) *rufipennis* Kennedy. FIGS. 7 and 8. The female of *Aeshna* (*Coryphaeschna*) *luteipennis florida* Calvert from Juan Vinas, Costa Rica, June 24, 1909, 3400 ft., Calvert collector.

head black except a semicircular pale spot crossed by four darker striae on each occipital auricle.

Prothorax black, edged with pale and paler on lower sides. Mesometathorax black with broad dark green markings. The antealar sulcus green, its carinae edged with black; the anterior carina black immersed in a black equilateral triangle; a broad black stripe nearly twice as wide above as below covering the humeral suture and a similar black stripe covering the second lateral suture wider below than above (figs. 1 and 3). The dorsal spots between wing attachments green. The ventral surface of thorax brown with the surface posterior to hind coxae probably greenish in life.

Wings tawny, less so in the median spaces; stigmas brown, veins black; legs black, except coxae, trochanters and bases of femora, all of which are brown.



FIGS. 9 and 10. Wings of allotype female of *Aeshna* (*Coryphaeschna*) *rufipennis* Kennedy.

Abdomen black with a broad tapering lateral green stripe on segs. 1–3 with its point reaching the middle vertical keel on seg. 4. It is interrupted by the apical black rings of segs. 1–3. The lateral stripe is a fusion of the usual spots AL, ML and PL (Walker, E. M., 1912, p. 9). Seg. 1 largely black above; seg. 2 with a narrow middorsal stripe from anterior and extending almost to the vertically narrow MD, the pair of PD forming a middorsal stripe with its widened end across the apex of the segment; 3 with MD a right-angled triangle and PD a minute dot; 4 similar dorsally but with a minute PL; 5 with an L-shaped AL, with MD and PD as in 4 and with no PL; 6, 7 and 8 with a minute dot for AL; and no other dorsal or lateral green; 9 and 10 wholly black. Ventral surface with segs. 1 and 2 brown, segs. 3 to 7 with the brown limited to paired areas; segs. 3 to 7, the entire pleural fold entad to the ventral keel brown; seg. 8 the brown limited to inner edge of anterior end of fold, with an

obscure pale area across posterior fourth of sternum. Base of stylus yellow and an obscure brown spot on side of seg. 9. Seg. 10, cerci, paraprocts and supra anal lobe black.

Structure.—Anal appendages (cerci) with parallel sides and obliquely rounded apices (fig. 5). The diagonal lateral ridge on ovipositor sheath sinuous (fig. 4). The spiny area on ventral surface of seg. 10 dumbell-shaped, viewed from below, its middle one-third as broad as either end. The lower edge of tergite above ovipositor sheath, viewed from the side, evenly rounded.

Comparison with female of Aeshna (Coryphaeschna) luteipennis florida Calvert.—In *florida* the anal appendages with an acute apex, the outer sheath of ovipositor with a straight diagonal lateral ridge and the anterior edge of tergite (fig. 8) with a more nearly straight diagonal profile of its anterior two-fifths. Otherwise we have found no differences between the female of *luteipennis* and the female of *rufipennis*. Apparently the color patterns do not distinguish the females of the two species at all easily. Fresh specimens might show color differences.

This female allotype is in the author's collection.

We wish to thank the University of Michigan for loan of material of Coryphaesehna and thanks to Prof. P. P. Calvert for loan of other Coryphaeschna specimens.[1]

[1]In a letter of August 5, 1944, Prof. P. P. Calvert, after examining the type of *rufipennis* ♀, pointed out that, (1) In *rufipennis* ♀ the second and third femora were reddish at extreme base only. (In *luteipennis*, reddish in proximal half.) (2) In *rufipennis* the occiput entirely black. (In *luteipennis*, with a dorsal and a posterior yellow spot.) Also that some females of *luteipennis* show a wavy rib on the side of the ovipositor.

ON THE CLASSIFICATION OF THE HISTERID BEETLES, by RUPERT L. WENZEL. Zool. Series, Field Museum of Natural History. Vol. 28(2): 51–151, pls. 1–9, 1944.

Besides much discussion of convergent evolution in this family and some rearrangement of genera and subfamilies, the greater part of the volume is given to the description of new genera and new species. Fifty-six new species are described.—C. H. K.

INDEX TO THE LITERATURE OF SIPHONAPTERA OF NORTH AMERICA, by WILLIAM JELLISON and NEWELL E. GOOD, F. S. A., U. S. Public Health Service, Nat. Institute of Health Bull. No. 178; 193 pages, paper bound. Supt. of Documents, Washington, D. C. Price $0.25.

The present very useful publication is a combined product of the Rocky Mountain Laboratory (Hamilton, Mont.) of the Division of Infectious Diseases, National Institute of Health and the Laboratory for Plague Suppressive Measures (San Francisco, Calif.) of the Division of State Relations. It covers the fleas north of Mexico, including Greenland, up to July 1, 1939. "Our publication is intended as a guide to the literature of the species and genera and is not a monographic treatment of the order."

The bibliography occupies pages 164 to 182, the index, pages 183 to 193.

—C. H. K.

MOSQUITO SURVEY ACTIVITIES AT CAMP PEARY, VIRGINIA[1]

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Early recognition was made of the fact that the mosquito control problem in Camp Peary would be one of magnitude and of immediate importance to the general training program. The Commanding Officer observed that mosquitoes were particularly troublesome during reconnaissance trips in late summer in 1942 in the vicinity of the proposed camp site. Local residents support these observations and readily attest that mosquitoes in past years, in this locality, have been numerous and annoying. The general region has a malaria history and active cases of malaria are still encountered, adjacent to the camp, during the mosquito season. The camp is located along a tidal river in eastern Virginia and in general is heavily wooded. In camp, salt marsh and freshwater breeding areas are extensive. There are three large and two smaller salt marsh areas; the freshwater drainage channels, creeks and small streams are numerous and many of the streams are spring-fed. The terrain varies from rolling hills to flat land; the maximum elevation in the south central region of the camp is about 90 feet above sea level. Generally speaking, the topsoil is a sandy loam underlain in many regions by a layer of sand which is on top of a firm clay subsoil. The area in which mosquito survey and control operations were conducted consisted of approximately 12,000 acres.

In accordance with the recognition that mosquito control would be a problem in Camp Peary and for the purpose of furnishing the mosquito control program with information relative to mosquito breeding necessary for effective control operations, formal mosquito survey activities were started by the entomologist of the Medical Department on April 9 and were continued until November 15. This mosquito survey was an integral and concurrent part of a control program and was not an investigational project; consequently many observations were necessarily omitted as time was a limiting factor. Before starting the survey it was determined that there were no available survey records from previous years for comparative use in formulating plans for the 1943 mosquito control program in Camp Peary. The data in this paper, though limited to one mosquito season, are presented with the hope that it will be helpful to mosquito control workers in comparable regions.

The success of the mosquito survey and control activities in Camp Peary during 1943 was augmented by the support and encouragement given by the Commanding Officer and the Senior Medical Officer.

[1]The expressions contained in this paper are the personal ones of the writer and are not intended to represent official views of the Navy Department.

I. ORGANIZATION OF THE MOSQUITO SURVEY UNIT

At the beginning of the survey, there were no trained personnel except the officer (entomologist) in charge; the latter carefully trained three chief petty officers and two rated men in mosquito survey and control methods. These men in turn assisted in training ten additional, selected, enlisted men; this detail constituted the nucleus from which the ultimate survey organization (20 men) was formed. The men that were trained for mosquito survey and control activities were selected, when possible, on the basis of their interest in the work and their previous biological and engineering training.

II. PRELIMINARY WORK OF THE SURVEY UNIT

The first field problem was that of locating all actual and potential mosquito breeding areas. A survey and study of the entire camp was conducted in which all springs, fresh-water streams, lakes, channels, swamps and saltmarshes were located and their limits defined. This survey was completed in two weeks by a detail consisting of three chief petty officers and three rated men. The courses and limits of the various bodies of water and drainage systems were plotted on a map of the camp area.

III. ORGANIZATION OF THE MOSQUITO SURVEY

The survey was based on two methods—larval inspection and adult mosquito collections. In larval inspection activities the potential breeding sites in camp were inspected for larvae approximately once each week. During one week the freshwater streams, springs, pools, etc., were inspected; the following week a "cross-country" plan was followed in which also all rainwater pools, borrow pits, roadside ditches, etc., were inspected; about once every three weeks the firebarrels, essential artificial containers, etc., were inspected and the saltmarshes were regularly inspected during periods of inundation. The average size of the larval inspection detail was ten men; they worked most efficiently in two men units. Each inspector was equipped with a hollow-handled, white enamel dipper (with a two foot stick inserted), a pipette (large size urethral syringe with tip enlarged), supply of screw-top glass bottles, field notebook, pencil and a supply of strips of white gauze. All breeding sites were marked by tying a strip of gauze to an adjacent twig or weed to assist the maintenance (control) crews in locating the site. Larval specimens were collected from each breeding site, placed in labeled bottles and taken to the laboratory for identification. For convenience the collections were numbered and recorded in consecutive order.

The adult mosquitoes were collected mechanically by means of New Jersey-type light traps and manually in buildings, barrels and from man used as an attrahent. Ten mosquito light traps were placed in strategic locations throughout the camp and were operated from dusk to daylight twice each week (Monday and Friday nights). In all cases the traps were located in representative areas adjacent to both fresh and saltwater breeding sites where possible. The traps were suspended by means of a pole and cross-arm device approximately five feet above

the ground and each location was marked by a conspicuous, numbered sign. Power for operating traps was furnished (each trap) by a 6 V. storage battery which operated both the rubber-bladed fan and the 21 candlepower bulb. The batteries (with steel loop attached) were secured to trees by means of a chain and padlock. It was necessary to recharge the batteries after each night of operation. In preparing the cyanide killing jars (quart Mason fruit jar), it was found that it is best to cover the cyanide with a layer of paper towels and then pour a thin layer of plaster of paris over the paper; jars having a thick layer of plaster have an incidence of breakage that is much higher. The insects caught in each trap were emptied into numbered cans (corresponding to trap numbers) and then taken to the laboratory for sorting, identification and counting.

TABLE I

ADULT MOSQUITOES COLLECTED
According to Trapping Methods

Type of Trap	Number of Specimens	Per Cent
Light Traps	13,295	83.5
House Traps	1,308	8.2
Barrel Traps	921	5.8
Man Traps	398	2.5
Total Specimens Collected	15,922	100.0

Adult mosquito collections were made by hand in selected locations such as barns, privies, stables, culverts, etc.; fifteen of these sites in camp were visited once each week and all adult mosquitoes present in each location were collected by means of a suction tube and a flashlight. The specimens were killed with ether fumes, placed in a pill-box with appropriate data and then taken to the laboratory for sorting and identifying.

In remote regions of the camp where no buildings existed, adult mosquito resting places were provided by placing wooden barrels (interior blackened) in selected sites. The barrels, with one end removed, were placed on their sides in wooded areas, and brush piled over the top. Each barrel location was marked with a conspicuous, numbered sign. These sites also were visited once each week and the specimens present in each barrel were collected and treated similarly to those collected in the regular mosquito collecting stations.

On the nights that the light traps were operated (twice weekly) adult mosquito collections were made from man, in the vicinity of sentries, at eight locations distributed over camp. The man was placed in the dark and was observed for three minutes at fifteen second intervals for the presence of mosquitoes on his body. A flashlight and suction tube are important items of equipment for this type of collecting. The specimens collected were treated similarly to those collected by other hand collecting methods.

The mosquito survey field notes were compiled each week; the information pertaining to kind, extent and location of breeding along with certain control recommendations was presented to the mosquito control unit in form of a weekly report. A "Jeep" proved to be an ideal means of transportation for all activities concerned with the mosquito survey program.

TABLE II

AVERAGE NUMBER OF MOSQUITOES TRAPPED PER HOUR IN EACH TYPE OF TRAP

Species	Light Traps	Barrel Traps	House Traps	Man Traps	Total Specimens
Anopheles					
quadrimaculatus	.05	1.85	1.47	.05	293
punctipennis	.76	.71	.78	.14	476
bradleyi	1.79	.26	2.34	.41	1,092
crucians	.15	....	.21	....	92
Aedes					
sollicitans	.30	.12	.13	.96	180
taeniorhynchus	4.45	1.31	.49	10.45	2,370
vexans	8.50	.19	.18	1.30	3,891
triseriatus	.06	....	....	.05	26
dupreei	.19	....	....	....	86
Culex					
salinarius	11.26	3.76	3.35	4.46	5,765
restuans	.55	.78	.32	.09	332
erraticus	.13	2.05	1.85	....	385
apicalis	.09	.59	.37	.05	117
Psorophora					
columbiae	.39	....	....	.18	181
ferox	.20	....	....	....	89
Theobaldia					
melanura	.01	4.20	.13	....	262
Uranotaenia					
sapphirina	.57	....	.01	....	259
Miscellaneous	.04	.07	.04	....	26
					15,922

IV. MOSQUITOES COLLECTED IN CAMP PEARY

Nine genera comprising thirty species of mosquitoes, (twenty-five species of adults and twenty-seven species of larvae), were collected during the 1943 season. The species list is as follows:

Anopheles
- *quadrimaculatus* Say
- *punctipennis* (Say)
- *crucians* Wied.
- *bradleyi* King
- *barberi* Coq.

Aedes
- *sollicitans* (Walk.)
- *taeniorhynchus* (Wied.)
- *vexans* (Meig.)
- *canadensis* (Theob.)
- *triseriatus* (Say)
- *dupreei* (Coq.)[3]
- *atlanticus* D. and K.[2]
- *cantator* Coq.[2]

Culex
- *salinarius* Coq.
- *restuans* Theob.
- *apicalis* Adams
- *erraticus* D. and K.
- *peccator* D. and K.[2]
- *quinquefasciatus* Say

Psorophora
- *columbiae* (D. and K.) (This name is now widely used for this species.)
- *ciliata* (F.)
- *ferox* (Humb.)
- *howardii* (Coq.)[2]

Theobaldia
- *melanura* (Coq.)
- *inornata* (Will.)

Mansonia
- *perturbans* (Walk.)[2]

Orthopodomyia
- *signifera* (Coq.)
- *alba* Baker[2]

Megarhinus
- *septentrionalis* D. & K.[2]

Uranotaenia
- *sapphirina* (O.-S.)

[2]Only larvae collected.
[3]Only adults collected.

TABLE III

SEASONAL RECORD OF ADULT MOSQUITOES COLLECTED BY THE MONTH, ACCORDING TO SEX

Species	April		May		June		July		August		September		October		November		Total Males	Total Females	Total Specimens Collected
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female			
Anopheles																			
quadrimaculatus	.....	.....	.....	.....	15	69	24	68	21	54	17	22	.....	6	.....	1	77	216	293
punctipennis	.....	.....	.....	45	24	149	13	128	4	39	4	72	.....	3	.....	.....	45	431	476
crucians	.....	.....	.....	.....	.....	.....	.....	18	1	63	.....	9	1	.....	.....	.....	2	90	92
bradleyi	.....	16	2	131	18	392	9	359	3	142	3	37	.....	8	.....	.....	35	1,057	1,092
barberi	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1
Aedes																			
sollicitans	.....	10	.....	14	1	84	1	157	.....	6	.....	7	.....	4	.....	1	2	178	180
taeniorhynchus	.....	.....	.....	.....	27	1,407	7	767	4	193	10	43	.....	4	.....	.....	48	2,322	2,370
vexans	.....	6	4	48	63	1,620	6	1,664	37	363	17	55	10	4	.....	2	137	3,754	3,891
canadensis	.....	.....	.....	.....	.....	.....	.....	1	.....	2	.....	.....	.....	.....	.....	.....	.....	4	4
triseriatus	.....	.....	.....	1	2	.....	.....	.....	.....	10	.....	2	.....	.....	.....	.....	2	24	26
dupreei	.....	.....	.....	.....	.....	.....	.....	54	.....	31	.....	1	.....	.....	.....	.....	.....	86	86
Culex																			
salinarius	.....	3	120	781	260	2,018	103	1,978	82	225	82	153	17	5	1	1	665	5,100	5,765
restuans	.....	.....	12	19	5	16	7	58	.....	22	87	72	19	14	.....	1	130	202	332
apicalis	.....	.....	11	38	9	48	1	7	.....	2	.....	1	.....	.....	.....	.....	21	96	117
erraticus	.....	1	.....	.....	.....	.....	4	26	48	77	16	69	12	49	6	80	86	299	385
peccator	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1
quinquefasciatus	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1	.....	1
Psorophora																			
columbiae	.....	.....	.....	.....	.....	19	2	106	2	56	.....	.....	.....	.....	.....	.....	4	177	181
ciliata	.....	.....	.....	.....	.....	.....	.....	1	.....	2	.....	.....	.....	.....	.....	.....	.....	3	3
ferox	.....	.....	.....	.....	9	19	1	48	.....	13	.....	.....	.....	.....	.....	.....	10	79	89
Mansonia																			
perturbans	.....	.....	.....	.....	.....	3	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	5	5
Orthopodomyia																			
signifera	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1	.....	.....	.....	.....	.....	2	2
Theobaldia																			
melanura	.....	.....	15	65	.....	53	4	113	.....	.....	.....	12	.....	.....	.....	.....	19	243	262
inornata	.....	1	.....	3	.....	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9	9
Uranotaenia																			
sapphirina	.....	.....	.....	1	26	123	1	25	9	25	8	38	.....	2	.....	.....	44	215	259
Totals	.....	37	164	1,147	459	6,025	183	5,343	211	1,263	244	594	59	99	8	86	1,328	14,594	15,922

A total of 15,922 adult specimens were collected and identified by all trapping methods (see Tables I and II). 83.5% of the total number were collected in light traps, 8.2% in house traps, 5.8% in barrel traps and 2.5% from man. The seasonal trapping record (all methods) of adult mosquitoes by species and by sex is presented in Table III.

TABLE IV

MOSQUITO LARVAE SURVEY, 1943

Collection Frequency

Species	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
Anopheles									
quadrimaculatus	....	....	2	7	62	26	6	3	106
punctipennis	8	27	81	94	187	91	45	24	557
bradleyi	....	3	12	2	5	3	9	....	34
crucians	....	....	....	....	2	....	....	....	2
barberi	....	....	4	3	1	....	....	1	9
Aedes									
taeniorhynchus	....	....	6	....	8	3	9	....	26
sollicitans	7	3	....	....	1	5	15	....	30
canadensis	27	5	....	....	....	....	....	....	32
vexans	6	9	15	52	32	26	23	3	166
triseriatus	6	6	14	14	21	4	8	13	86
atlanticus	....	2	....	3	1	....	....	....	6
cantator	....	....	....	....	....	2	6	....	8
Culex									
salinarius	....	38	48	51	60	12	2	....	211
restuans	42	85	84	79	169	100	193	125	877
apicalis	52	36	84	93	230	137	47	34	713
erraticus	....	....	1	5	88	33	9	2	138
quinquefasciatus	....	....	....	....	1	24	8	7	40
Psorophora									
columbiae	....	3	7	83	49	17	1	....	160
ferox	....	1	1	1	5	3	....	....	11
ciliata	....	2	2	4	3	....	....	....	11
howardii	....	....	1	....	7	1	....	....	9
Theobaldia									
inornata	10	....	....	....	....	....	1	....	11
melanura	....	....	....	2	....	2	1	....	5
Uranotaenia									
sapphirina	....	....	1	1	12	....	....	....	14
Orthopodomyia									
signifera	....	....	7	6	27	8	8	23	79
alba	....	....	....	....	....	....	....	1	1
Megarhinus									
septentrionalis	....	1	2	7	7	3	5	6	31

Twenty-seven species of larvae were collected as listed in Table IV, by months, by species; these numbers do not indicate the total number of specimens, but rather the number of times (different locations) in routine larval inspection that they were collected. Two thousand eight hundred and thirty larval collections were made during the season. Observations on larval distribution and larval (species) associations are presented in Tables V and VI; these tables are similar to those used by Owen (8).

For purpose of reference and for use in the malaria control training program, specimens of adults and larvae were preserved. The adult mosquitoes were both pinned and preserved unmounted; permanent slide mounts were prepared of the male hypopygia of various species. Larvae were preserved in alcohol and also by means of permanent slide mounts.

TABLE V

DISTRIBUTION OF MOSQUITO LARVAE COLLECTED[4] FROM DIFFERENT TYPES OF PLACES

Species	A	B	C	D	E	F	G	H	I
Anopheles									
quadrimaculatus	6	25	9	1	....	....	....	....	257
punctipennis	75	313	89	08	7	2	....	....	90
bradleyi	2	17[5]	1[5]	8[5]	....	....	12	....	....
crucians	1	....	4	....	....	....	....	....	1
barberi	....	....	....	....	....	8	....	....	....
Aedes									
taeniorhynchus	....	3	4	....	....	....	17	3	....
sollicitans	....	....	....	....	....	....	19	11	1
vexans	....	65	66	28	....	2	7	....	5
canadensis	1	16	1	14	....	....	2	2	....
triseriatus	....	2	3	....	8	90	....	....	1
atlanticus	....	1	3	1	....	....	1	....	....
cantator	....	....	....	....	....	....	11	....	....
Culex									
salinarius	8	92	19	39	12	3	7	3	23
restuans	49	451	178	222	75	39	....	1	63
apicalis	71	419	102	129	7	4	2	....	55
erraticus	2	7	2	4	2	1	....	....	307
quinquefasciatus	....	8	10	2	19	....	....	....	....
Psorophora									
columbiae	1	11	129	7	....	....	....	....	4
ferox	....	1	8	....	....	....	1	....	....
ciliata	....	2	12	....	....	....	....	....	1
howardii	....	2	5	1	....	....	....	....	1
Theobaldia									
melanura	....	3	....	....	1	1	....	....	....
inornata	....	3	1	1	....	....	4	....	....
Orthopodomyia									
signifera	....	1	1	1	8	66	....	....	2
alba	....	....	....	....	....	1	....	....	....
Megarhinus									
septentrionalis	....	....	....	....	2	36	....	....	....
Uranotaenia									
sapphirina	....	3	....	2	....	....	....	....	37

A—Running freshwater in streams or ditches.
B—Quiet freshwater pools in streams and channels.
C—Small rainwater pools and road ruts.
D—Freshwater seepage pools.
E—Artificial freshwater containers (cans, jars, etc.).
F—Treeholes.
G—Brackish water pot holes and small grassy pools.
H—Brackish water in drainage ditches above high tide or not functioning.
I—Freshwater artificial lake (margin).

[4]Number of times collected.
[5]Region formerly salt marsh area; water now almost fresh.

TABLE VI

Species Associations of Mosquito Larvae[6]

Species	*An. quadrimaculatus*	*An. punctipennis*	*An. bradleyi*	*An. crucians*	*An. barberi*	*Ae. sollicitans*	*Ae. taeniorhynchus*	*Ae. vexans*	*Ae. canadensis*	*Ae. triseriatus*	*Ae. atlanticus*	*Ae. cantator*	*C. salinarius*	*C. restuans*	*C. apicalis*	*C. erraticus*	*C. quinquefasciatus*	*P. columbiae*	*P. ciliata*	*P. ferox*	*P. howardii*	*T. melanura*	*T. inornata*	*O. signifera*	*O. alba*	*M. septentrionalis*	*U. sapphirina*
Anopheles																											
quadrimaculatus	33	50	1	3	....	....	....	7	....	1	....	....	10	14	40	211	....	6	....	....	....	....	....	1	....	....	25
punctipennis	50	139	8	1	....	....	....	69	1	3	....	....	72	191	342	54	3	15	2	5	2	1	1	....	....	....	10
bradleyi	1	8	8	....	....	5	5	2	3	1	....	3	6	6	18	1	1	1	....	....	....	....	....	....	....	....	..
crucians	3	1	....	....	....	....	....	....	....	....	....	....	....	....	1	1	....	....	....	....	....	....	....	....	....	....	....
barberi	....	....	....	....	....	....	....	....	....	7	....	....	1	....	....	....	....	....	....	....	....	....	....	6	....	2	....
Aedes																											
sollicitans	....	....	5	....	....	15	11	3	5	....	....	2	1	3	2	....	....	....	....	....	....	....	3	....	....	....	....
taeniorhynchus	....	....	5	....	....	11	9	2	2	....	....	....	3	....	3	1	....	1	....	....	....	....	....	....	....	....	....
vexans	7	69	2	....	....	3	2	100	1	1	....	....	10	32	29	3	....	36	4	5	2	1	1	....	....	....	....
canadensis	....	1	3	....	....	5	2	1	21	....	....	....	1	5	13	....	....	....	....	....	....	....	....	....	....	....	....
triseriatus	1	3	1	....	7	....	....	1	....	65	....	....	4	7	2	....	....	2	....	....	....	....	....	30	....	11	....
atlanticus	....	....	....	....	....	....	....	....	....	....	1	....	....	1	....	....	....	3	....	1	....	....	....	....	....	....	....
cantator	....	....	3	....	....	2	....	....	....	....	....	4	....	1	1	....	....	....	....	....	....	....	....	....	....	....	....
Culex																											
salinarius	10	72	6	....	1	1	3	10	1	4	....	....	55	88	74	7	1	5	1	1	....	1	....	2	....	....	3
restuans	14	191	6	....	....	3	....	32	5	7	1	1	88	569	261	15	19	12	1	3	1	1	2	10	....	3	1
apicalis	40	342	18	1	....	2	3	29	13	2	....	1	74	261	216	28	6	19	1	3	2	2	3	1	....	....	13
erraticus	211	54	1	1	....	....	1	3	....	....	....	....	7	15	28	72	....	4	1	1	2	....	....	2	....	....	26
quinquejasciatus	....	3	1	....	....	....	....	....	....	....	....	....	1	19	6	....	18	....	1	....	....	....	....	1	....	....	....
Psorophora																											
columbiae	6	15	1	....	....	....	1	36	....	2	3	....	5	12	19	14	....	97	2	1	6	....	....	....	....	....	1
ciliata	....	2	....	....	....	....	....	4	....	....	....	....	1	1	1	1	....	2	5	2	....	1	....	....	....	....	....
ferox	....	5	....	....	....	....	....	5	....	....	1	....	1	3	3	1	....	1	2	....	....	....	....	....	....	....	....
howardii	....	2	....	....	....	....	....	2	....	....	....	....	....	1	2	2	....	6	....	....	1	....	....	....	....	....	1
Theobaldia																											
melanura	....	1	....	....	....	....	....	1	....	....	....	....	1	1	2	....	....	....	1	....	....	....	....	1	....	....	....
inornata	....	1	....	....	....	3	....	1	....	....	....	....	....	2	3	....	....	....	....	....	....	....	4	....	....	....	....
Orthopodomyia																											
signifera	1	....	....	....	6	....	....	....	....	30	....	....	2	10	1	2	1	....	....	....	....	1	....	31	1	18	....
alba	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....
Megarhinus																											
septentrionalis	....	....	....	....	2	....	....	....	....	11	....	....	....	3	....	....	....	....	....	....	....	....	....	18	....	16	....
Uranotaenia																											
sapphirina	25	10	....	....	....	....	....	....	....	....	....	....	3	1	13	26	....	....	....	....	1	....	....	....	....	....	1

[6]Number of times collected together.

V. CLIMATOLOGICAL CONSIDERATIONS

Climatological data from 1933 to 1943 inclusive for the Williamsburg, Virginia, region were obtained from the U. S. Weather Bureau at Richmond, Virginia. The seasonal weather data for 1943 are presented in Table VII. Weather conditions were observed each night of light trap operation for the purpose of trying to determine the effects of weather on the efficacy of light traps.

TABLE VII

TEMPERATURE (°F.)

Month	High	Low	Mean	Mean High	Mean Low	Normal (10 years)
April	89	21	55.0	69.9	40.2	56.7
May	91	29	69.2	81.8	56.5	66.1
June	96	61	79.1	90.1	68.1	73.6
July	95	50	77.8	88.1	67.5	77.4
August	96	50	76.6	88.6	64.6	76.2
September	97	38	68.4	81.9	54.9	70.9
October	84	31	57.5	71.3	43.7	60.4
November	78	20	50.9	68.2	33.6	49.7

RAINFALL (inches)

Month	Actual	Normal (10 years)	Wind Direction (Prev.)
April	2.86	3.78	SW
May	5.10	3.89	SW
June	4.35	4.71	SW
July	6.55	6.20	SW
August	1.79	5.83	SW
September	4.03	3.24	N
October	2.78	2.81	SW
November	1.89	2.40	SW

VI. DISCUSSION

In comparing the results of the various adult mosquito trapping methods, (Table I), it must be borne in mind that the ten light traps were operated for a total of two hundred hours each week; the fifteen house traps were operated for a total of two hours, the fifteen barrel traps for a total of one hour, and the eight man traps for a total of forty-eight minutes. It is apparent, (Table II), that certain species are more readily collected in one type of a trap than in another. For instance, *Anopheles quadrimaculatus* was collected more frequently in barrel and house traps than in light traps; *Aedes taeniorhynchus* was collected more frequently from human beings than by any other method of trapping. The relative prevalence of the various species during the mosquito season is also indicated in Table II. It is believed that climatological conditions directly influence the effectiveness of light

traps. In all instances the largest collections were made on warm, dark, humid nights; the effectiveness was reduced more by moonlight than by rain or wind. 75.4% of the total numbers of adult mosquitoes trapped (all methods) were collected during June and July; the mean low temperatures for these months were 68.1° and 67.5° F. respectively, (Table VII), and the rainfall was close to the normal for the last ten years, (almost eleven inches for both months). It is probable that adult mosquitoes would have been more prevalent during August had not this been a hot and unusually dry month; this year the rainfall was 1.79 inches as compared with the normal of 5.83 inches. The first *Anopheles quadrimaculatus* male was collected on June 12 and the last collection was made on September 25; the corresponding collection dates for female *quadrimaculatus* were June 7 and November 12, respectively. *Culex quinquefasciatus* did not appear until late in the season; an adult male was collected during the first week of November.

Mosquito larvae were more numerous during the months of July, August, September and October, (Table IV). The distribution of larvae collected from different types of places, (Table V) and species association, (Table VI), in general, compares favorably with the observations of other workers. There are, however, some uncommon variations in species associations and interesting occurrences of mosquito larvae. The tree-hole mosquitoes, *Aedes triseriatus* and *Orthopodomyia signifera*, occurred in several locations other than tree-holes, notably in artificial, freshwater lakes. *Orthopodomyia alba* larvae were collected only once during the season, November 13; they were collected together with *Orthopodomyia signifera* from a hole in a stump that extended above the surface of an artificial, freshwater lake. The occurrence of *Megarhinus septentrionalis* larvae in artificial containers and *Culex erraticus* in a tree-hole is of interest. *Anopheles quadrimaculatus* larvae were collected on several occasions in freshwater, artificial lakes, the surface of which was completely covered with *Lemna*. In studying the distribution of the larvae of potential disease-carrying mosquitoes of this locality, it was determined that *Anopheles quadrimaculatus* larvae were collected most frequently along the weedy margins of freshwater, artificial lakes. *A. punctipennis* was found more often in quiet, freshwater pools in streams and drainage channels. *A. crucians* was collected mainly in small, rainwater pools. *Culex quinquefasciatus* larvae occurred commonly in artificial containers and small rainwater pools. Pest mosquito larvae were usually collected in the types of locations with which they are commonly associated. *Aedes sollicitans* and *taeniorhynchus* were generally taken in brackish potholes and grassy, saltmarsh pools. *Culex restuans* and *Aedes vexans* were collected most frequently in quiet, freshwater pools in streams and channels; however, the latter species was taken as often in small, rainwater pools and roadruts. *Psorophora ciliata* and *columbiae* occurred mainly in rainwater pools and roadruts. *Culex salinarius* larvae were collected in every type of breeding location encountered, but they were most numerous in quiet, freshwater pools in streams and channels.

Field observations pertaining to the number of times the different species of mosquito larvae were collected together are presented in

Table VI. The habitats in which the larvae were found are divided into nine types, (Table V), each constituting a different kind of community. Certain species occurred concurrently with other species frequently enough to indicate that the particular habitat provided a community mutually suitable for their development and that the species are probably ecologically similar or equivalent, depending on the species. *Anopheles quadrimaculatus* larvae were associated with *Culex erraticus* 211 times, with eleven other species 158 times and they were collected alone 33 times. *A. quadrimaculatus* was taken in 298 different (random) larval collections; 257 of these collections were from artificial, freshwater lake margins and 41 from four other types of habitats (Table V). *Culex erraticus* larvae, as stated previously, were associated with *A. quadrimaculatus* 211 times, with fourteen other species 146 times and they were collected alone 72 times. They were taken in 325 different (random) larval collections; 307 of these collections were from artificial, freshwater lake margins and 18 from six other types of habitats (Table V). *Uranotaenia sapphirina* was associated with *Anopheles quadrimaculatus* and *Culex erraticus* more often than with other species. *Anopheles punctipennis, Culex restuans* and *C. apicalis* were collected most frequently in quiet, freshwater pools in streams and channels. Likewise, *Aedes sollicitans, taeniorhynchus* and *Anopheles bradleyi* occurred in similar habitats. Other examples of apparent associations of mosquito larvae are presented in Table VI. These associations are not only of ecological interest, but when definitely established, can be of practical value in mosquito control operations. Species control is recognized as being of primary importance in the control of disease-carrying mosquitoes. The presence of larvae that are commonly associated with those of disease-carrying mosquitoes in a certain type of habitat, even though the latter is not present at that time, is an indication either that control measures should be instigated or the location should be kept under close surveillance.

VII. SUMMARY

For the type of mosquito survey conducted at Camp Peary in 1943, each of the four methods of collecting adult mosquitoes, (light traps, house traps, barrel traps, human beings), was useful and each supplemented the other. When storage batteries must be used to operate light traps, the heavy duty type should be selected. The operation of light traps on bright, moonlight nights did not give an accurate indication of the mosquito population present on those nights. It is essential, for successful operation of barrel traps, that they be located in carefully selected sites and that they simulate a hollow log as nearly as possible. In collecting mosquitoes from man at night, satisfactory results were obtained by having the man strip to the waist. Adult mosquitoes were most prevalent this year during the months of June and July; it is believed that adverse (dry) weather conditions in August caused them to be less numerous than usual during that month. The 1943 records indicate that the active mosquito breeding season in Camp Peary begins in April and continues through October; these dates coincide very well with the average dates (10 years average) of killing

frosts in the Spring, (April 9), and Fall, (October 31), for this region. By planning mosquito control activities accordingly, optimum results can be expected. In general, the distribution of mosquito larvae was similar to that observed by other workers; there were exceptions, particularly among tree-hole breeders in which instances they were collected in sites other than tree-holes. The presence of one or more species of larvae definitely associated with the larvae of disease-carrying mosquitoes, in particular types of breeding locations, can be recognized as an indication of the necessity for mosquito (species) control.

The data included in this paper are not conclusive because they are the results of only one season's activities and additional work in this region would be desirable, especially for purposes of verification of certain of these observations.

LITERATURE CONSULTED

(1) **Boyd, M. F.** Studies on the bionomics of North American anophelines. I. The number of annual broods of *An. quadrimaculatus*. Amer. Journ. Hyg. 7, pp. 264–275.
(2) **Boyd, M. F.** Ibid. 11. Physical and chemical factors in their relation to the distribution of larvae in Northeastern Carolina. Ibid. 9, pp. 346–370, 1929.
(3) **Boyd, M. F.,** and **Weathersbee, A. A.** Ibid. V, Winter activities of anopheline imagines in coastal North Carolina. Ibid. 9, pp. 682–694, 1929.
(4) **Bradley, G. H.** Some factors associated with the breeding of Anopheles mosquitoes. Journ. Agri. Res., Vol. 144, No. 5, pp. 381–399, 1932.
(5) **Dunn, L. H.** Further observations on mosquito breeding in tree-holes and crab-holes. Bull. Ent. Res. 18, pp. 247–250, 1928.
(6) **Howard, L. O., Dyar, G. D.,** and **Knab, F.** The mosquitoes of North and Central America and the West Indies. Carnegie Inst. of Wash., Vol. 1, 1912.
(7) **King, W. V., Bradley, G. H.,** and **McNeel, T. E.** The mosquitoes of the southeastern states. U. S. D. A. Misc. Pub. No. 336, pp. 96, 1942.
(8) **Owen, O. B.** The mosquitoes of Minnesota with special reference to their biologies. Univ. of Minn. Agri. Exp. Sta. Tech. Bul. 126, pp. 76, 1937.
(9) **Russell, P. F., Rozeboom, L. E.,** and **Stone, A.** Keys to the Anopheline mosquitoes of the world. Amer. Ent. Soc., pp. 152, 1943.
(10) **Simmons, J. S.,** and **Aitken, T. H. C.** The Anopheline mosquitoes of the northern half of the western hemisphere and of the Philippine Islands. The Army Med. Bul., No. 59, pp. 213, 1942.

THE ANOPHELINE MOSQUITOES OF THE CARIBBEAN REGION, by W. H. W. Komp. lx+195 pp., 155 figs. National Institute of Health Bulletin 179. Federal Security Agency, U. S. Public Health Service, Washington, D. C. 1942. For sale by the Superintendent of Documents, Washington, D. C. Price 35 cents.

This bulletin is based largely on original comprehensive studies made by Mr. Komp. Thorough descriptions and keys are given for adult females, larvae, and male terminalia of twenty-two species. The illustrations are excellent and the detailed studies of male terminalia, made according to the recent suggestions of Mr. Komp, will elicit particular interest. There are some thirty-five pages of general information, a bibliography, and an index.

An appendix consists of keys, in Spanish, to adult females, larvae, and male terminalia; an interlinear translation into Spanish of descriptions of the female, larva, and male terminalia of *Anopheles albimanus;* a list of entomological terms in English, Spanish, and Portuguese; and a section on susceptibility of the discussed species to malaria infection and ability as vectors of malaria.

—C. E. Venard.

A KEY TO THE ANOPHELES OF THE SOUTHEASTERN UNITED STATES, BY MALE GENITALIA (Diptera, Culicidae), by LOUIS M. ROTH, in the American Midland Naturalist, Vol. 30, No. 1, pp. 96–110, January, 1944. The University Press, Notre Dame, Indiana.

This key to the 10 species of *Anopheles* found in the Southeast: *barberi, albimanus, atropos bradleyi, crucians, georgianus, pseudopunctipennis, punctipennis, quadrimaculatus,* and *walkeri,* is illustrated with 61 figures. Sufficient specimens of the common anophelines were available to enable the author to include data on variation of structures which are of taxonomic value.—C. E. VENARD.

INSECTOS DO BRASIL, by A. DA COSTA LIMA. 1938–1943. Ser. Didatica No. 2, da Escola Nacional de Agronomia, Rio de Janeiro, Brazil.

By some turn of fate the ANNALS has just received a second copy of volume three of this extensive work. In the pages of the ANNALS have appeared notices of the four volumes which have covered the insects with incomplete metamorphosis and the Panorpata, Suctoria, Neuroptera and the Trichoptera. The work is a well illustrated compendium of what is known of the great insect fauna of that vast country. We take this opportunity to summarize the parts which have appeared to date.

Tomo 1. (1938). Pages X and 470. Chaps. 1 and 2, General facts; 3, Thysanura; 4. Collembola; 5, Ephemerida; 6, Odonata; 7, Perlariae; 8, Embiidina; 9, Orthoptera; 10, Grylloblattoidea; 11, Phasmida; 12, Dermaptera; 13, Diploglossata; 14, Blattariae; 15, Mantodea; 16, Isoptera; 17, Zoraptera; 18, Corrodentia; 19, Mallophaga; 20, Anoplura; 21, Thysanura.

Tomo 2. (1940). Pages 1–351. Hemiptera.

Tomo 3. (1942). Pages 1–327. Homoptera.

Tomo 4. (1943). Pages 1–141. Panorpatos; Suctórios Neurópteros; Tricópteros.

We wish Costa Lima opportunity to finish this great work.—C. H. K.

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